POWER PLANT ENGINEERING

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Paper Mill Treats Feed Water Twice

BRYANT PAPER CO. HAS TWIN-CYLINDER UNIFLOW ENGINE, ONE CYLINDER RUN CONDENSING. BOILER PRESSURE IS 300 LB. AND THE STEAM TEMPERATURE IS 620 DEG. F.

PROBABLY NO ONE industry in this country is making more rapid progress towards the practice of greater economy and more efficient methods than is the paper industry. One instance of this progressiveness is that of the modern improvements being made at the Bryant Paper Co. of Kalamazoo, Mich. With the completion of their present program the Bryant group of mills will be a fine example of the modern paper mill.

To carry out the present program it has been necessary to discontinue the use of the old power units and to build a new central power plant to supply the mill group with electric power, high and low-pressure steam and hot and cold water. A great deal of the success in high-grade paper making depends upon certain processes being supplied with pure water. This is being taken care of at the Bryant mills by an elaborate but essential water softening system.

At the present time the new power plant is furnishing power, heat and water to three out of the four divisions or mills, which are known as the Bryant, Imperial, Milham and Superior divisions. Electric power, high and low-pressure steam and hot and cold water are being furnished to the Bryant division. The same service is being extended to the Superior division and the electric power is tied in with the Milham division.

Ample provision is made for extension to the power plant to care for a more complete electrification of the

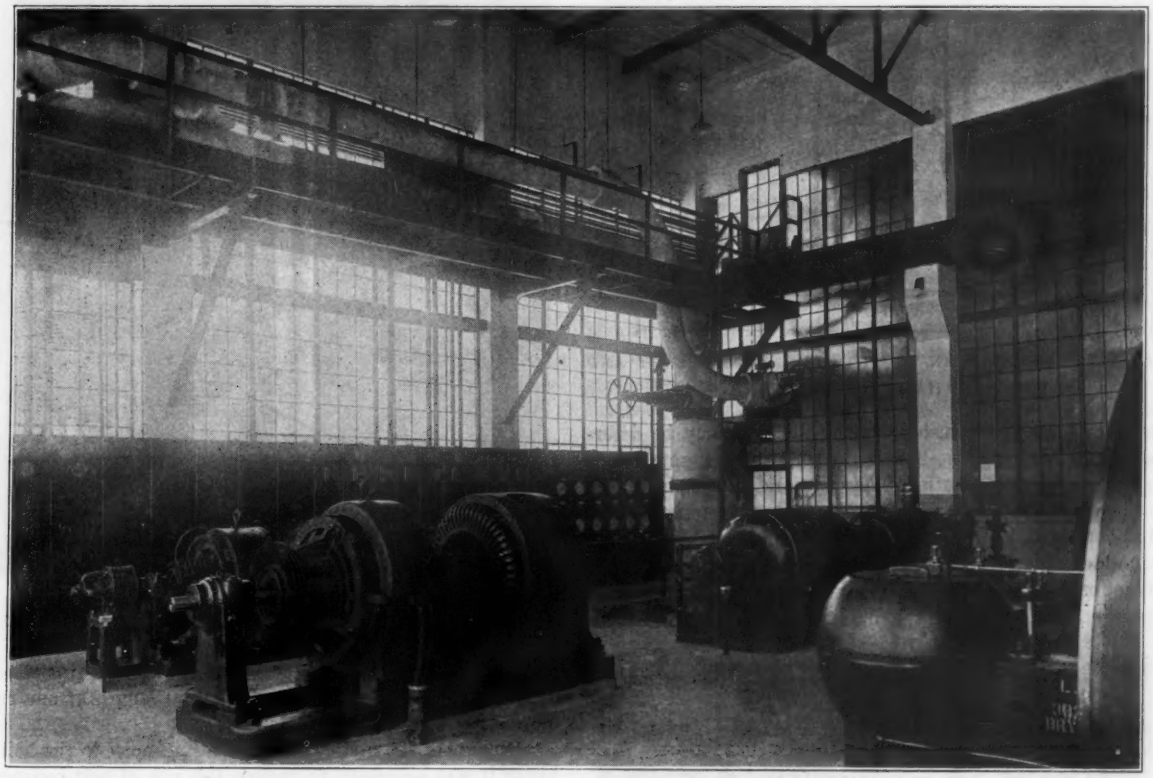


FIG. 1. SOUTHWEST CORNER OF THE GENERATOR ROOM SHOWING STEEL SASH BETWEEN THIS ROOM AND THE BOILER ROOM

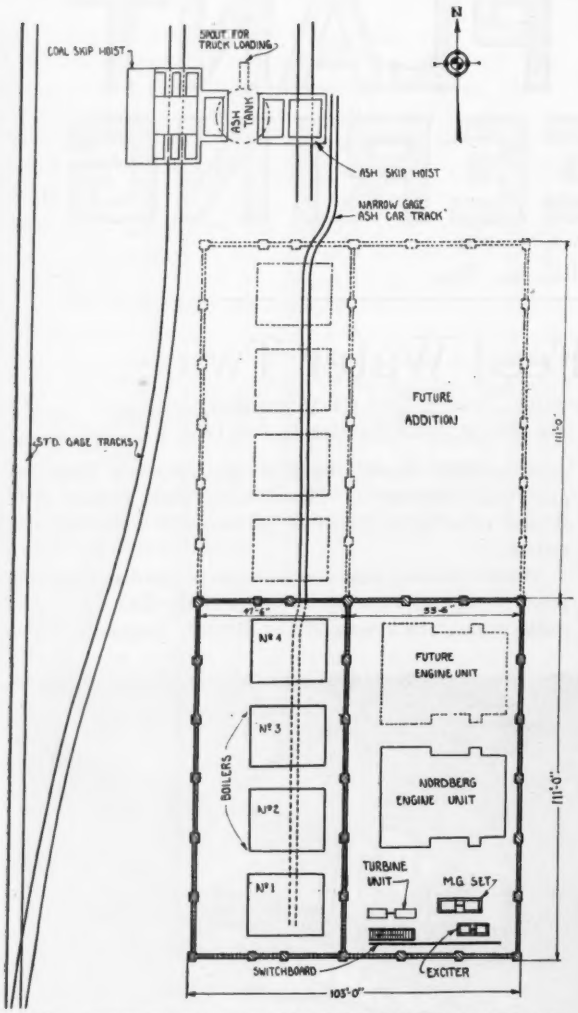


FIG. 2. GENERAL PLAN OF THE NEW POWER PLANT AND THE COAL HANDLING SKIP HOISTS

mills or possible extensions to the mills as may be determined at a later date. The main boiler and engine rooms extend north and south. The permanent wall is to the south while the north wall is of temporary construction so that both additional boiler and generating units can readily be added at a future date. The temporary wall construction is interesting in that it is made up of steel framework covered on the outside with corrugated galvanized steel sheeting and on the inside with a composition mill board and contains no windows.

In the planning for future extensions, the coal and ash handling skips have been located to the north of the boiler room a distance of approximately 150 ft. This will allow space for power plant additions which will just double the capacity of the present new power plant. These additions can be made without altering the present coal and ash handling equipment which has been installed with sufficient capacity to take care of future requirements.

Coal is delivered to the plant by railroad. The coal cars may be switched out into the north yard and unloaded by a Link-Belt Co. locomotive crane when it is desired to store coal or the cars may be dumped into a concrete track hopper equipped with an automatic loader, which feeds coal to a counterbalanced skip hoist rated at 75 T. per hr. and capable of handling about 100 T. per hr.

The hoist elevates the coal through a vertical lift and discharges it into a crusher which can be bypassed and

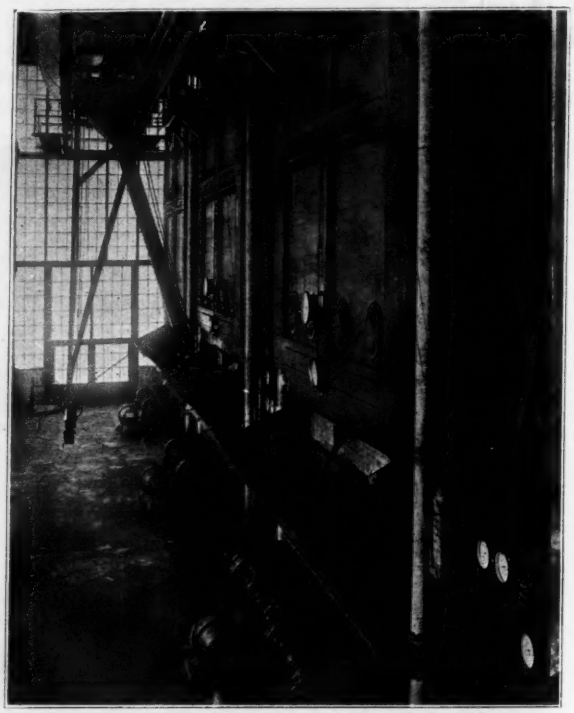


FIG. 4. FOUR 800-HP. BOILERS HAVE BEEN INSTALLED

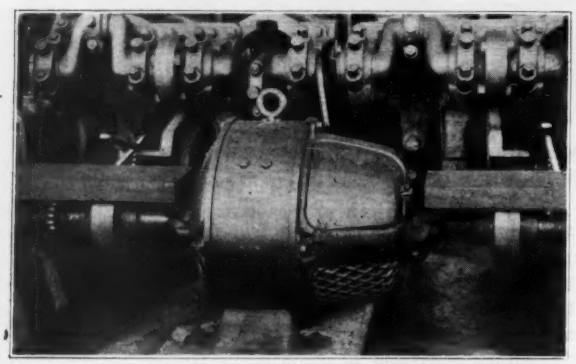


FIG. 3. STOKERS ARE DRIVEN THROUGH TWO CHAINS

which in turn unloads the coal onto a belt conveyor which extends into the boiler room. The total length of one run of the belt is about 260 ft.

Because of the distance from the skip hoist to the boiler house it was necessary to enclose the run of belt conveyor between them. This was accomplished by building an enclosed gallery which is sufficiently wide for the conveyor and a walkway and high enough for a man to walk through it without stooping. This gallery is of steel construction, floored with planking and sided with galvanized iron. The roof is covered over with cement tile. The gallery is supported on steel frames.

Located over the boiler room firing aisle is a suspended coal bumper the capacity of which is 450 T. This is made of steel and is unlined but is treated with a bitumastic

cement which is effective in reducing corrosion and wear. The cross members at the top of the bunker are of steel encased in concrete. The belt conveyor passes over the center of this bunker and is provided with a motor-driven traveling unloader so that coal may be unloaded at any point over the bunker. All the coal handling equipment was furnished by the R. H. Beaumont Co. and is motor-driven throughout. The belt conveyor is motor-driven through a W. A. Jones Fdry. and Mach. Co. geared speed reducer.

Belt Conveyor Partitioned off From Economizer Room

The space around the belt conveyor is completely enclosed so that coal dust will not reach the main boiler

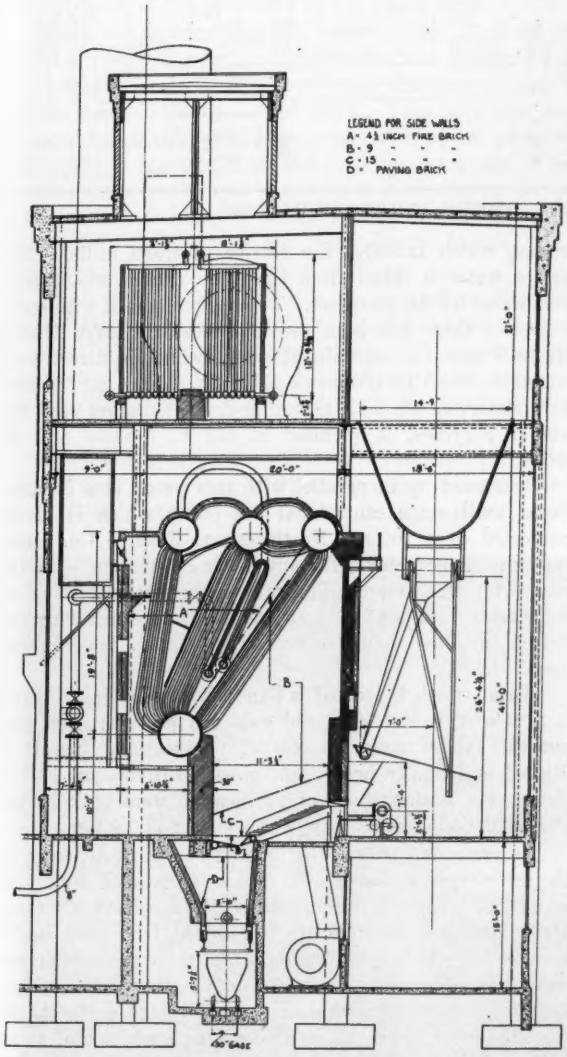


FIG. 5. SECTIONAL ELEVATION THROUGH A BOILER SETTING AND AN ECONOMIZER

room. The south and west walls of this space are provided with steel sash. The curtain wall between the bunker space and the boiler room is constructed of a steel frame covered on both sides with expanded metal and a cement plaster.

Distribution of coal from the overhead bin to the stoker hoppers is accomplished by means of a weigh carrier which

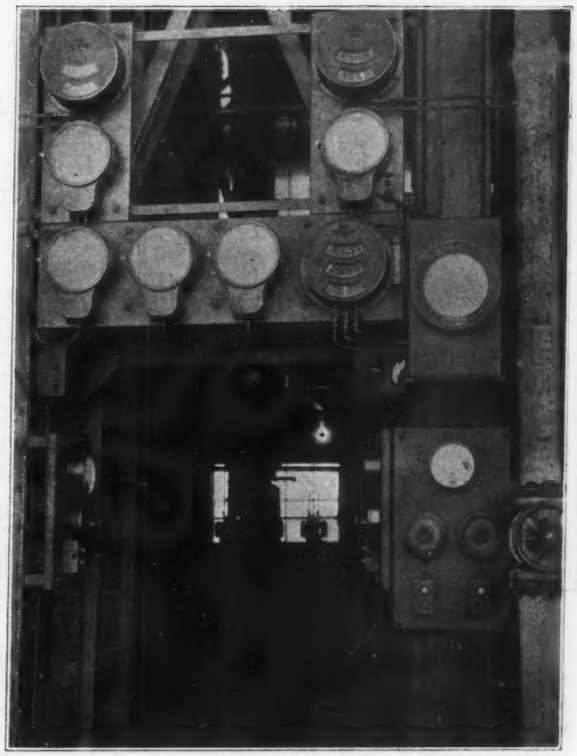


FIG. 6. AUXILIARY CONTROL PANEL AND RECORDERS ARE MOUNTED AT EACH BOILER

travels the full length of the hopper. In this way the full hopper capacity is active at all times and an accurate account can be kept of the coal consumed by each boiler.

Ash from the air operated stoker dump plates is discharged into reinforced concrete ash hoppers which are suspended beneath the stokers. These hoppers are brick lined and each hopper is provided with two ash gates. Narrow gage steel dump cars pass in under these hoppers and carry the ash out to a skip hoist located just east of the coal skip hoist. Here also is provided an overhead ash tank which is made of steel and which will hold about one and one-half carloads of ash. An interesting and valuable feature of this installation is that the ash skip hoist will also handle coal so that it is a stand by coal hoist as well as an ash hoist.

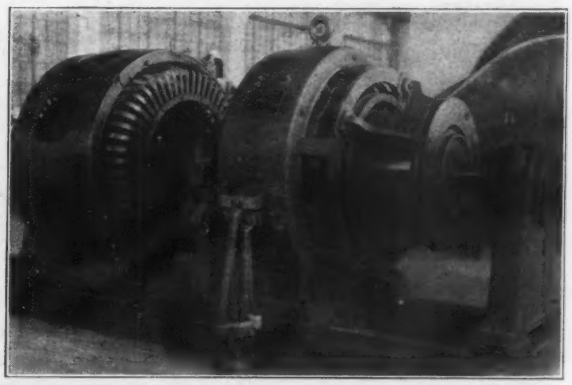


FIG. 7. MOTOR-GENERATOR SET SUPPLIES DIRECT CURRENT FOR AUXILIARIES

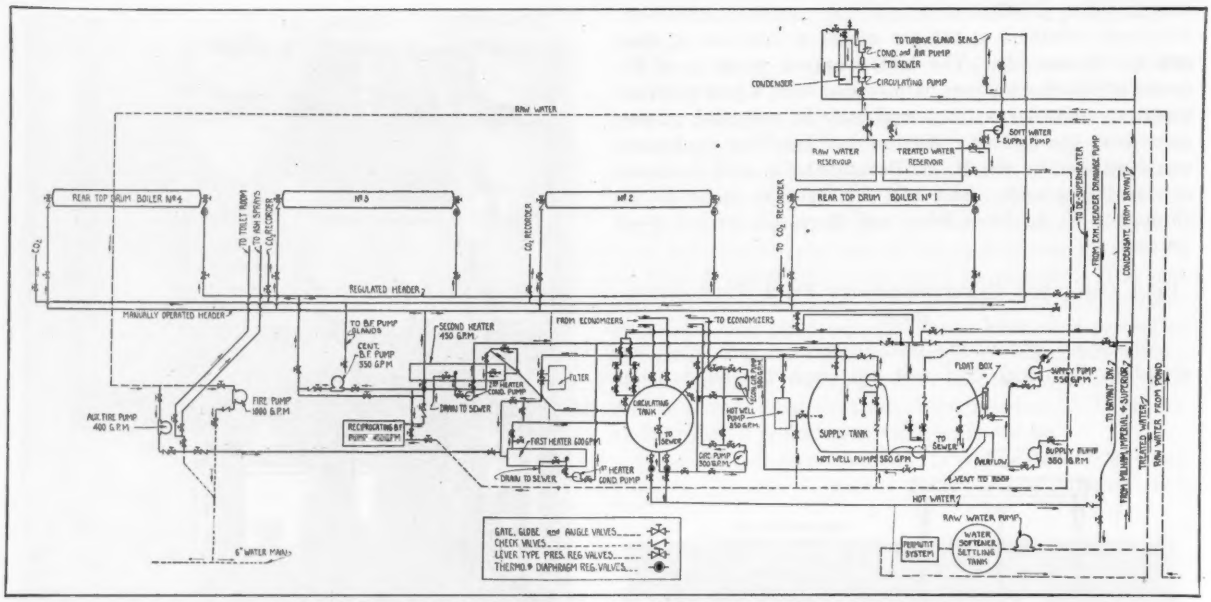


FIG. 8. FLOW DIAGRAM OF FEED WATER THROUGH PUMPS AND HEATERS

A railroad switch serves this ash skip, both for the removal of ash and the unloading of coal. The construction of the ash track within the boiler room basement is such that the quenching water will drain off in a trench located between the rails. This trench is covered over with cast-iron grid plates. The stoker ash gates and the dump plates are actuated by air pressure which is supplied by means of a small Westinghouse locomotive type air compressor.

Water Supply Taken From Portage Creek

Running through the property of the Bryant Paper Co. is a small stream known as Portage Creek. This is the source of all the water used in these paper mills. To assure a normal supply of water under all conditions a dam has been thrown across the creek. The overflow from the dam is allowed to go to waste until a portion of it is passed through a small automatic hydroelectric plant of 100 kw. capacity which is in parallel with the new power plant.

Water as it comes from the pond is not suitable for all the processes of paper making nor is it suitable for boiler feed purposes. It is suitable, however, for general mill service, which includes fire service at these mills. The service water is taken from the same system which supplies water for fire purposes. To supply the mill with service water there has been provided a single stage Union Steam Pump Co. centrifugal pump which is direct connected to an Allis-Chalmers Mfg. Co. 25-hp. a.c. motor. This motor, as are all alternating-current motors used for similar purposes, is operated at 440 v., 3-phase and 60 cycles.

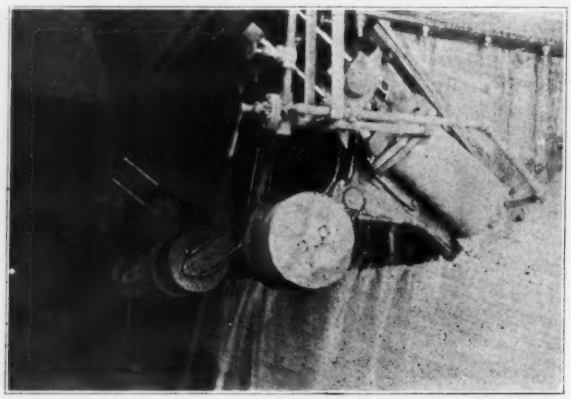


FIG. 9. ASH GATES ON STOKER HOPPERS ARE OPERATED BY AIR PRESSURE

Connected up in parallel with this pump is a Dayton-Dowd multi-stage centrifugal fire pump which is direct connected to a 100-hp. Northwestern Electric Co. alternating-current motor. An automatic starter has been installed for this motor. The pressure normally carried on the service lines is 65 lb.. In addition to the motor-driven unit a turbine-driven fire or service pump has also been installed.

Water which is treated is handled in four steps. First it is treated by the lime and soda ash process; it is next put through a zeolite process of purification, then it is filtered and finally heated and passed through an Elliott deaerator. Both systems of purification were built by the Permutit Co. and they have a capacity of 600 g.p.m.

As previously stated, the first step in purification is by the use of lime and soda ash. These ingredients are mixed in a large vat which is equipped with a mechanically operated agitator. The mixture is pumped from this vat to another vat which is located on top of the coagulant or settling tank. This tank is erected out of doors and is housed over to protect the overhead lime and soda ash vat, the feeding device and a vat which contains a solution of alum. Inside of this tank is a cone into the top of which the raw water and lime and soda ash solution is discharged. About half way down this cone is located the outlet from the alum vat. The flow of water is downward in the cone so that the sludge which settles out of the water is carried to the bottom of the tank where it may be drained off to the sewer.

Raw water is delivered to this tank by a single-stage, Union Steam Co. centrifugal pump driven by a Westinghouse induction motor. The flow of water of this tank is

ingeniously regulated by a float which is located in a small tank connected to the main tank by a small opening. This prevents the float from following the surges of the water in the tank and so giving unsatisfactory regulation. The chemicals used for treating the water are proportioned according to the amount of raw water flowing by a tilting pan device which lowers the intake pipes in the lime and soda ash solution and the alum solution vats.

After the water has received this preliminary treatment which reduces its hardness about one-half, it is picked up by another induction motor-driven Union pump and forced through filters from which it passes to the zeolite softener where its hardness is reduced to zero. From the softener the water is discharged into a concrete storage tank located in the basement of the boiler house.

From the storage tank the water is picked up by two motor-driven Union centrifugal pumps and delivered into an overhead hot well or supply tank, the rate of flow to which is regulated by a float valve. This tank acts as a surge chamber into it all high-pressure drips are returned. The water is removed from this tank by either one of two motor-driven centrifugal pumps or a direct acting duplex steam pump, the size of which is 7½ by 8½ by 10 in. The centrifugal pumps are each driven by an Allis-Chalmers induction motor rated at 25 hp.

These pumps deliver the water through a Griscom-Russell filter and closed heater to a vertical tank which is in series with the economizers. This tank is virtually a circulating tank from which the mill hot water supply is taken. The pressure maintained up to the feed pumps is 65 lb.

Automatic controls cut off the hot water supply to the mills if the temperature of the water drops below 200 deg. F. or if the pressure falls below 65 lb. gage. This avoids

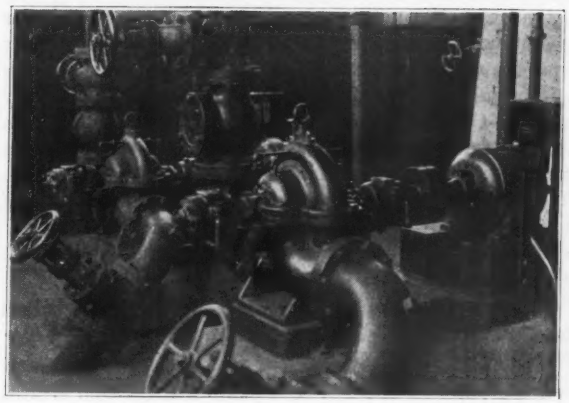


FIG. 10. THESE PUMPS DELIVER FEED WATER TO THE SURGE TANK

the possibility of the mills robbing the economizers. The circulation through the economizers and this tank is forced by means of two motor-driven single-stage centrifugal pumps.

In this installation the economizers carry a double load. In addition to the boiler feed water, all hot water used for process works in the mill, equal to from 25 to 40 per cent of the quantity evaporated in the boilers, is heated in the economizer. As a result of this increased heat absorption the final temperature of the flue gas is reduced to below 300 deg. F.

From the circulating tank that portion of the water used for boiler feed passes through another Griscom-Russell closed heater where its temperature is raised to about 230 deg. F. From the heater the water still under 65 lb. pressure, goes to the boiler feed pumps which deliver

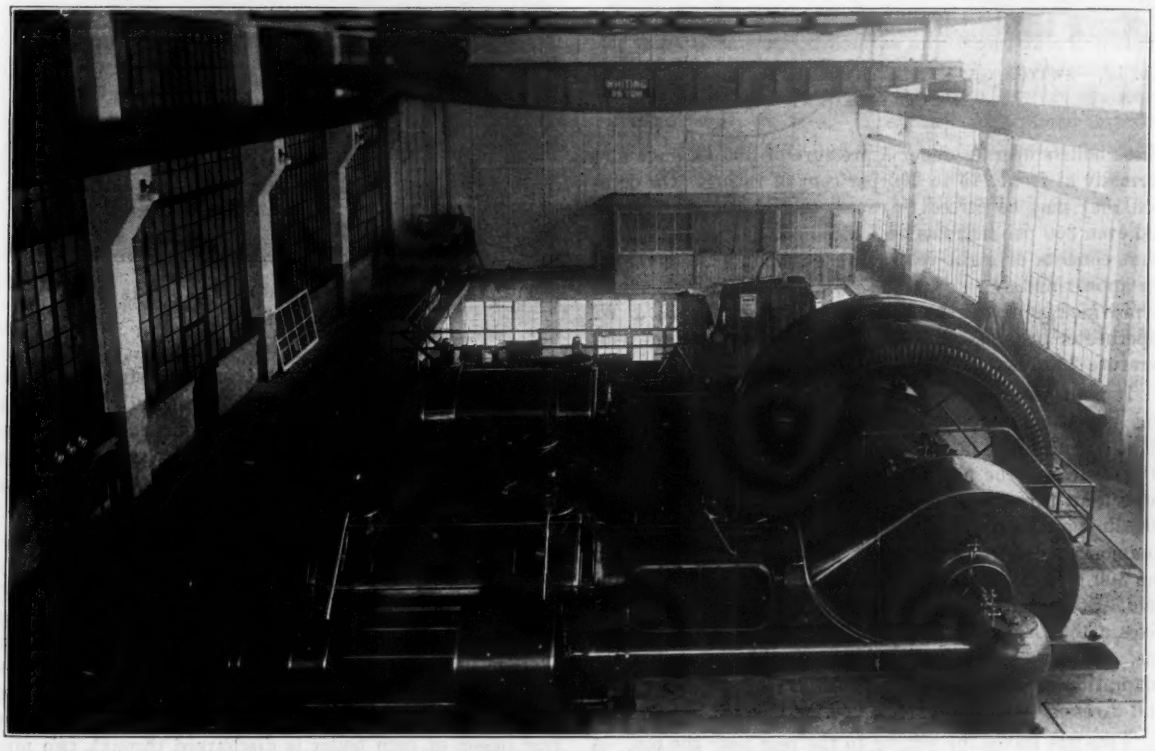


FIG. 11. TWIN CYLINDER, 2500-KW. NORDBERG UNIFLOW UNIT

to the boilers through two duplicate feed lines. One boiler feed pump is a Worthington duplex outside packed plunger type, the size of which is 20 by 12 by 15 in. The other is a Worthington multi-stage pump which is driven direct by an Allis-Chalmers 100-hp. 440-v. induction motor. In addition to these two there is also provided a smaller steam turbine-driven centrifugal unit having a capacity up to 2000 boiler hp. which is put into service during periods of light load. All boiler feed pumps are controlled by S-C constant excess pressure governors the differential of which is held at about 50 lb.

Feed water enters the rear upper drums of the boilers and is controlled through S-C regulators.

Raw water is piped so that it can be picked up directly by the steam-driven boiler feed pump and the cold treated water is piped to both feed pumps. These connections are for use in case of emergency.

Four Stirling boilers, each rated at 780 hp. are set singly. The rear or mud drums are 10 ft. above the floor which gives a large combustion space above the stokers.

FIG. 12. SWITCH GEAR FROM THE MAIN BOARD IS MOUNTED IN THE BASEMENT

These boilers operate under a pressure of 300 lb. gage and normally at from 175 to 200 per cent of rating. On occasion they may be forced in excess of 300 per cent rating and even 350 per cent has been attained. The stoker equipment consists of eight retort Frederick underfeeds which are approximately 14 ft. wide. Standard Stirling baffling is provided and each boiler is equipped with a B. & W. superheater in the second pass which raises the steam temperature 200 deg. F.

It is of some special interest to note here the pressure and superheat employed. Notwithstanding that power plant engineers are now talking with more or less assurance of pressures in the neighborhood of 1200 lb. there are not more than three or four plants in the country employing 600 lb. pressures. While it is becoming more and more common to find central station plants using pressures in the 300 to 400 lb. range, they are scarce in the industrial field. Steam at 300 lb. pressure and 200 deg. F. superheat gives a total steam temperature of some 620 deg. F. and has, of course, necessitated special precautions in the adaptation of prime movers and in providing against leaks and excessive strains.

Flue gas leaves the setting in the rear near the top. A steel breeching carries the gas from two boilers to a Greene economizer, which raises the water temperature 125 deg. F. where 300 g.p.m. is flowing. There is one economizer for each two boilers. One motor-driven Clarage induced draft fan takes the gas from each economizer and discharges it through a steel breeching to a steel stack which is supported on the building structure. One stack serves all four boilers. Diamond soot blowers are standard equipment on both boilers and economizers. The breeching is so arranged that the economizers may be bypassed.

The breeching inside the building is insulated on the outside. That portion of the breeching which is outside of

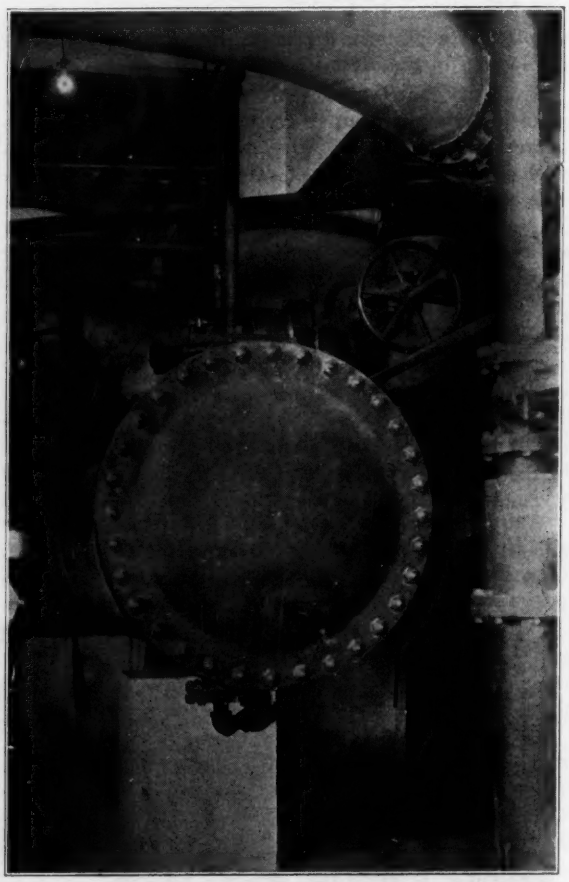


FIG. 13. MAIN LOW PRESSURE HEADER IS 36 IN. IN DIAMETER

the building, or above the roof and the stack up to the breeching connections are insulated internally. All safety valves are piped through the roof. The connection between each safety valve and the riser is made by means of a short length of flexible metallic tubing. This takes care of all expansion and contraction.

Stokers Are Motor Driven

Each stoker is chain driven by a Westinghouse direct-current motor rated at 7.5 hp. 230 v., 400 to 1600 r.p.m. The forced blast equipment consists of four individual Clarage fans driven by Westinghouse motors. These fans are located in a basement room which is provided at one end with a louvre for air admission. Soot from the two rear passes of each boiler is discharged through two pipes into the ash hopper.

Control of the induced draft fan and the forced blast fans is accomplished by means of the Gray system of control, made by the Automatic Fuel Saving Co. This system controls the speeds of the direct-current motors driving these units through a special Westinghouse control board. The action of the system is entirely automatic. Air for the Gray control is furnished by an automatic compressor furnished by the Brunner Mfg. Co. Stoker speeds are regulated from boards mounted at each boiler.

Each boiler is equipped with the following instruments:

1 Tycos flue gas temperature recorder.
1 Tycos steam temperature recorder.
1 Foxboro draft and blast pressure recorder.
1 Republic recorder.
1 Republic flow meter.

There is also one Tycos two pen recorder to show the water temperature rise through each economizer. Indicating gages are provided for boiler pressure and the pressure in each boiler feed line.

Equipment in the main generating room consists of one Westinghouse motor-generator set which is used as an exciter. The synchronous motor is rated at 290 hp., 80 per cent power factor, 1200 r.p.m., 2200 v. 3-phase and 60 cycles. The generator is rated at 200 kw. and 250 v. The exciter for the motor is mounted direct. In the event of failure of this unit excitation for the main engine-driven unit can be taken either from the Milham division or from the house service bus by cutting in these sources of energy at the switchboard.

Direct current is furnished by means of a motor-generator set the synchronous motor of which is rated at 432 hp., 220 v., 3-phase, 60 cycles and 1200 r.p.m. The generator of this unit is rated at 300 kw. and 250 v. This is also a Westinghouse unit, the motor of which is separately excited. In addition to this provision is also made for tying in with a 1000 kw. synchronous motor-generator set at Milham for parallel operation of the two stations.

The third unit located in this room is an Allis-Chalmers non-condensing turbo-alternator which is rated at 500 kw. at 80 per cent power factor, 3-phase, 60 cycles and 3600 r.p.m. The exciter is direct connected and is rated at 56 amp. and 125 v. This unit, although operating in parallel, is used only during non-paper making hours.

Dependence for the main supply of electric current is placed upon a Nordberg variable compression uniflow engine which is direct connected to a separately excited Westinghouse alternator rated at 2500 kv.a., 2400 v., 3-phase, 60 cycles and 120 r. p. m. This engine is equipped with two high-pressure cylinders, that is, twin cylinders, each of which is 28 in. in diameter and the stroke is 48 in. The piston speed is 960 ft. per min. The piston and tail rods are 8 in. in diameter. The flywheel is 16 ft. in diameter, weighs 40 T. and its rim speed is approximately 6000 ft. per min. The main bearings are 17¾ by 36 in.

One extremely interesting feature of this engine is the exceedingly low water rate that is obtained. Manufacturer's guarantee, which has been borne out in acceptance tests, show a steam consumption, with 275 lb. initial pressure 200 deg. F. superheat and 10 lb. gage back pressure, at ½ load, of 21.4 lb.; at ¾ load, 19.9 lb. and at full load 19.5 lb. per kw.-hr.

Each cylinder is equipped with a six-pump Richardson-Phenix mechanical forced-feed lubricator which supplies oil to the two sets of metallic packing, the two inlet valves and at two points in the cylinder. The lay shafts which actuate the valves and on which the governors are mounted, are driven from the main shaft by drag cranks and bevel gears.

Forced feed oil pumps are driven from the lay shafts. These pumps deliver oil to an over-head tank from which the oil flows by gravity through sightdrop feeders to all external engine bearings. Continuous filtering for the bearing oil is provided by a Richardson-Phenix filter.

One Engine Cylinder May be Run Condensing

This engine was installed with the idea of running one cylinder non-condensing and the other cylinder either condensing or non-condensing depending upon the demand for low-pressure steam. Accordingly an automatic device has been provided which shifts the load from the condensing to

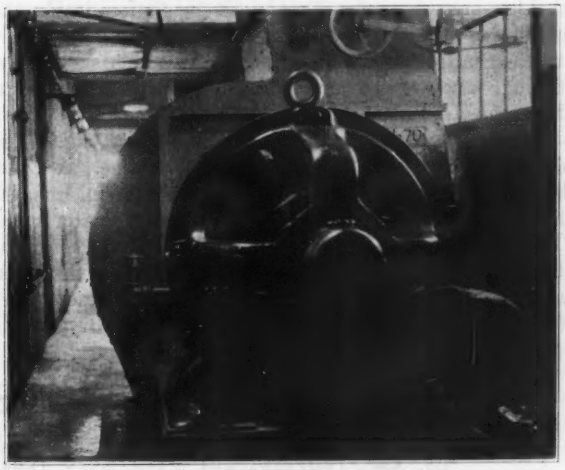


FIG. 14. EACH BLAST FAN IS DRIVEN BY A DIRECT CURRENT MOTOR

the non-condensing cylinder as mill requirements demand. A surface condenser has been provided for the one cylinder. This is a Union Steam Pump Co. surface condenser having 1800 sq. ft. area. When all contemplated improvements have been put into effect the most desirable station heat balance will be obtained by operating both cylinders non-condensing at all times. In that case, of course, there will be no further use for the condenser.

High-pressure steam for these cylinders enters a receiver near the engine from which a lead branches off to each cylinder. A Strong, Carlisle & Hammond automatic stop valve is located in each lead. These valves are interconnected and are remote controlled.

Westinghouse Electric & Manufacturing Co. furnished the main switchboard. All transformers and switch gear are located in the basement. Mounted on this board are the following Republic flow meters:

Total flow of feed water.
Steam to Nordberg Unit.
Steam flow from boiler No. 1.
Steam flow from boiler No. 2.
Steam flow from boiler No. 3.
Steam flow from boiler No. 4.
Steam flow to Allis-Chalmers turbine.
Steam flow to auxiliaries.
Steam flow to Bryant division.
Steam flow to Milham division.

A 25-T. Whiting electric crane travels the full length

of the generator room. Floor space remains for the addition of another unit similar to the Nordberg engine-driven alternator.

General construction of the generator room is of concrete with steel roof trusses and crane girders. Ventilated steel sash extends on two sides and the partition wall between the boiler and generator room is also of steel sash. The lights in this latter wall are wire glass. Three drop lights hang from the ceiling in each bay and a bracket lamp is located on each crane column. The roof is of concrete tile.

All piping, valves and fittings throughout the plant were furnished by Crane Co. All 300 lb. steam lines are equipped with Sargol welded joints and all 150 lb. lines have either the Van Stone or Crane lap joints. Cast steel valves are used exclusively throughout the plant, even on the low-pressure water lines. All insulation inside the plant was furnished by Johns-Manville and that outside by the Smith-Totman Co. Steam leaves each superheater through a non-return valve which is equipped with a Payne Dean remote control device. The boiler leads are 8 in. in diameter. A 10-in. lead goes to the Nordberg engine and a 4-in. lead goes to the Allis-Chalmers turbine. A 12-in. branch of the main header which is also a 12-in. line, extends to a receiver in the south end of the generator room. Two leads leave this receiver, one a 12-in. which goes to the Bryant division through an overhead gallery and the other, also a 10-in., which goes through another overhead gallery to the Milham division. These leads to the Bryant and Milham divisions must be under a pressure of not over 160 lb. and without superheat. Therefore, just ahead of the receiver in this line there is located a manifold to which three 6-in. gate valves are attached. Above each gate valve is a Schutte&Koerting spray nozzle which directs cold water into the 12-in. header. The effect of this water is to desuperheat the steam. An 8-in. pressure regulating valve is located between this manifold and the boilers.

All high-pressure drips are taken care of by the S-C system of drainage. Low-pressure drips from the closed feed-water heaters and the 36-in. main low-pressure header are provided with receivers from which the water is removed by small motor-driven centrifugal pumps.

The blowoff connection from the boilers is made to a vented steel tank which is located in the basement of the generator room.

Low-pressure steam is furnished by the Nordberg engine, the Allis-Chalmers turbine and the auxiliaries. Some exhaust steam goes to the closed feed-water heaters but most of it is supplied through 30 and 36-in. lines to the Milham and Bryant divisions.

Oil separators are located on all exhaust lines from engines and direct-acting pumps. The low-pressure lines are also amply protected by atmospheric relief valves.

Improvement of the Bryant Paper Co.'s property at Kalamazoo is under the direction of Felix Pagenstecher, president of the company. V. D. Simons, consulting engineer of Chicago, designed and supervised all improvements and building construction for the company.

Piping for High Pressure and Temperature

WITHIN A COURSE OF SEVERAL YEARS STEAM PRESSURES HAVE JUMPED FROM 250 TO 1200 LB. AND TEMPERATURES HAVE BEEN INCREASED TO 800 DEG. F. BY ROGERS A. FISKE

PRESENT DAY practice is tending decidedly towards the use of high steam pressure and temperatures. Although there is as yet no great amount of practical operating data available on this subject, it would unquestionably be an error to continue installing plants under pressure and temperature conditions which prevailed even 5 to 10 yr. ago.

For several years, plants in this country have been operating a 350-lb. boiler pressure with temperatures up to 650 deg. F. In Europe, considerable experience has been had particularly with high superheats. At the present time, plants are under construction in this country which will operate at from 550 to 650-lb. pressure and with steam temperatures approximating 750 deg. F. Boilers are also being built which will operate at 1200-lb. pressure. The design problem presented by the use of high pressures is not considered difficult, in fact it is no more difficult to design a valve for 600-lb. pressure than it would be to design it for a pressure of 200 lb. The problem becomes complex when high temperatures are considered.

To build a valve to withstand a high pressure means merely the addition of properly distributed metal but, when the temperature is increased from 450 to about 800 deg. F., certain physical characteristics of the metal have changed. Its strength has been reduced and certain metals which could be used for high pressure and low superheat cannot be used for high pressures and high superheats.

It will no doubt be well at this point to state briefly the reasons for high temperatures. The higher the initial temperature, of the steam on its admission to a heat engine, the better will be the efficiency of operation. This is due both to the greater proportion of heat available for conversion into mechanical energy and to the fact, in the case of the steam turbine, that the thermodynamic efficiency is improved by an increase in the total temperature or superheat. At the present time, it would appear that 800 deg. F. is a practical maximum for steam temperature. This, however, does not limit the designer in the selection of a pressure. It means simply that the higher the pressures selected the lower will be the superheat because the total or maximum temperature must, for the present at least, be held at or below 800 deg. F.

Materials available for power plant piping are subject to the conditions outlined above and in addition there will be a tendency for the pipe to oxidize at high temperatures. The charts given herewith show the change in physical properties for steel and wrought-iron pipe. The curves for steel pipe indicate that all kinds of carbon steel pipe lose about the same percentage of their original strength at high temperatures.

From present knowledge, it would appear that the selection of steel pipe for high temperatures and pressures would rest with the use of high-carbon seamless steel or lap-welded steel pipe made by the open-hearth process and rephosphorized up to 0.07. The carbon content would be about 30-point. At present a great amount of experimental work is being done in an endeavor to make iron with a high percentage of chromium, which is extremely resistant to oxidation and has valuable physical properties. The problem is difficult in the case of lap-welded pipe

because the welding quality of the steel is of prime importance.

To determine the thickness, for various working pressures, of either open hearth or Bessemer welded wrought-steel pipe, Crane Co. has developed the following formula:

$$P = 2 \times E.\,L. \times (t - 0.08) \div (4 \times D) \quad (1)$$

and

$$t = 2 \times P \times D + 0.08 \div (E.\,L.) \quad (2)$$

in which P equals the working pressure in lb. per sq. in. above atmosphere, t equals the thickness of the pipe in inches, D equals the outside diameter of the pipe in inches and E. L. equals the elastic limit of the material at the temperature considered. The figure 4 in the denominator of formula (1) is to be used for lap-welded pipe. When figuring for butt-welded pipe, use the factor 5. These formulas take into consideration all the important considerations which must be met when using high temperatures and pressures.

Standard or full weight pipe in the smaller sizes is good for much higher pressures than those for which it is now

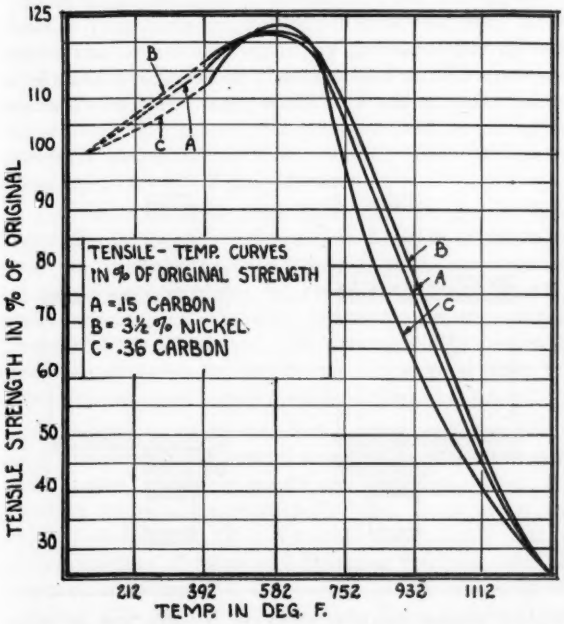


FIG. 1. CURVE SHOWING THE EFFECT OF TEMPERATURE UPON THE TENSILE STRENGTH OF 15 TO 36-POINT CARBON STEEL

commercially used. In the formula given above, the constant 0.08 is introduced to make allowance for corrosion or pitting, pipe stress due to expansion and irregularities. This constant affects the smaller sizes of pipe more than the larger sizes and so makes the pipe calculated by the formula conform to the general practice which experience has proved to be most satisfactory.

Friction Losses in Superheated Lines

Pressure drop of superheated steam in pipe lines can probably best be calculated by the formula

$$P = CW^2L\left(1 + \frac{3.6}{d}\right) \div (Vd^5) \quad (3)$$

in which W equals the weight of steam passing in pounds per minute; P equals the difference in pressure between the two ends of the pipe in pounds per square inch; L equals the length of the pipe in feet; V equals the density of steam or weight per cubic foot, which should be taken as the mean of the densities at the initial and final pressures; d equals the internal diameter of the pipe in inches; and C is a coefficient which may be taken at 0.000,132,1 for pipes smaller than 4 in. diameter when used in long runs and at moderate pressures. For larger pipes, especially with wet steam the formula may be written

$$P = CW^2L \div (Vd^5) \quad (4)$$

with the coefficient C varying from 0.000,313,5 to 0.000,355,7 depending upon the wetness of the steam and the roughness of the pipe.

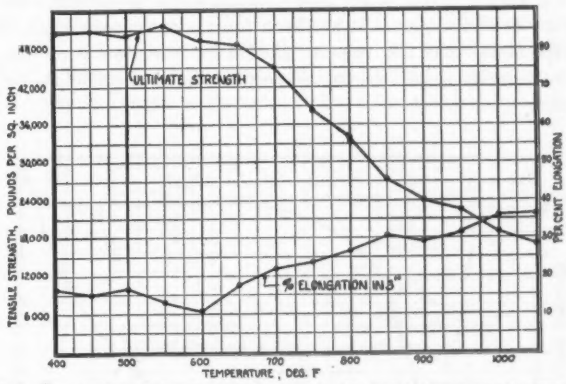


FIG. 2. EFFECT OF TEMPERATURE ON WROUGHT-IRON PIPE

For superheated steam with low temperatures and low velocities, so that the wall temperature is lower than that of saturated steam and the walls are therefore covered on the inside with a film of water, the pressure drop is approximately the same as for dry saturated steam.

With higher temperatures, higher velocities and higher wall temperatures so that the pipe remains dry inside, the coefficient C for superheated steam varies not only with the diameter of the pipe but also with the velocity, the pressure, the absolute temperature and the density. The friction losses agree closely with the results obtained by Fritsche whose suggested formula for C is as follows:

$$C = 0.000,002,2\ (R/144)^{0.148}(T/PW)^{0.148}d^{-0.269}$$

where

T = absolute temperature deg. F.; P = absolute pressure, lb. per sq. in.; W = velocity, feet per sec.; d = pipe diameter in ft.; R = 85.7 for steam.

So far, practically all formulas have been derived from tests in which the pressure did not exceed 300 lb. per sq. in. Where it has been possible to make observations at higher pressures, however, the drop in pressure has been less than would be expected, if the foregoing formulas were correct for high pressures. It is probable that the pressure drop in straight lines carrying superheated steam of 300 to 600-lb. pressure is from 10 to 25 per cent less than that calculated by the use of existing formulas for moderate pressures. A comparison of results made at pressures between 250 and 440 lb. with those obtained by using the Fritsche formula bears out this statement.

Pressure Drop in Fittings

Some experimental work has been done to determine the pressure drop in fittings and bends. The resistance to flow, which can readily be expressed in equivalent lengths of straight pipe, has been found to be considerably higher than formerly supposed. It is a fairly well established

fact that most of the pressure drop in pipe lines takes place in the bends, fittings and valves, especially the latter.

Steam velocities may be high in high-pressure pipe lines, provided the runs are long and that the steam flow is steady. Velocities may range from 10,000 to 15,000 ft. per min. If a line carrying high-pressure steam has a number of fittings, bends and valves, or if the steam flow is pulsating as for steam engines, it will be advisable to keep to the lower velocities in order to avoid excessive pressure drop.

High cost of large pipe necessitated by low velocities and the strength of material required for higher pressures is a factor to be taken into consideration in determining the size of the pipe. It has been found, in the case of small pipe sizes, that the velocity should be low; for 2-in. pipe the velocity should be in the neighborhood of 2000 ft. per min.

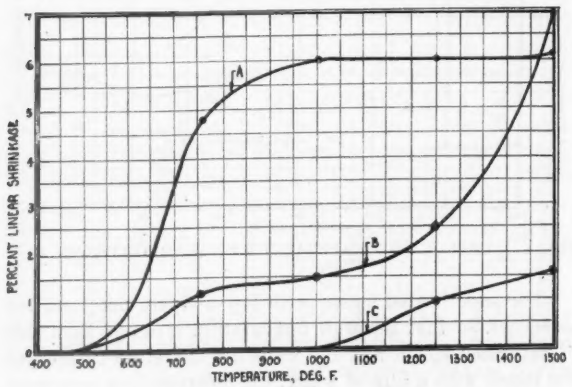


FIG. 3. SHRINKAGE OF VARIOUS INSULATING MATERIALS AT HIGH TEMPERATURES

For 6-in. pipe, the velocity can be well above 6000 ft. per min. In the larger sizes of steam pipe the ordinary maximum steam velocity can be about 15,000 ft. per min.

Heat Transmission Through Pipe Walls

Tests indicate clearly that the behavior of superheated steam is different from that of saturated steam as far as imparting heat to a metallic wall is concerned. This is due to the fact that saturated steam, in transferring heat to the wall, partly condenses or gives up some of its latent heat, which heat is not as closely combined with the steam as is the sensible heat of a liquid or the heat of superheat.

It has been shown that, for either saturated or superheated steam, the coefficient of heat transmission to the surrounding air remains practically constant up to a steam temperature of about 350 deg. F. and tends to increase at higher temperatures. For superheated steam flowing in covered pipes, the total heat transmission coefficient, in B.t.u. per sq. ft. per hr. per deg. F. temperature difference, varies, with a 2-in. covering, from 0.47 at 212 deg. F. to 0.69 at 750 deg. F. For bare pipe, the corresponding figures are 2.50 B.t.u. at 212 deg. F. and 4.81 B.t.u. at 750 deg. F.

It has also been shown that the velocity of superheated steam in a pipe has an influence on heat transmission. At a velocity of about 100 ft. per sec. and steam temperatures of 550 to 730 deg. F., the temperature difference between the steam and the pipe wall was 61 deg. F. With a steam velocity of 33 ft. per sec. the difference between the steam and pipe-wall temperatures was greater. By decreasing the velocity of the steam one-third, the coefficient of heat transmission between superheated steam and the pipe wall was decreased to one-half of the first value.

In the selection of insulating materials to be used with high temperatures, great care must be exercised to obtain material which will not shrink more than one per cent and which will not disintegrate or crumble after it is put in service. Experiments are now being conducted by using a double-thick covering, the inner layer of which is used primarily to protect the outer layer from the extreme heat. The inner layer will not disintegrate at high temperatures. All sectional insulation should be applied with both butt and lateral joints staggered. The pipe covering at the flanges should be cut back and beveled so that the bolts may be withdrawn without damaging the covering.

Joints For High-Pressure Steam Lines

Pipe joints for high-pressure steam is a subject upon which there is some divergence of opinion. At present it would seem that there are three types which may be used; namely, Sargol welded, Van Stone, and tongue and groove. The Sargol joint does not use a gasket and it has all the good features of the Van Stone joint. Objection has been

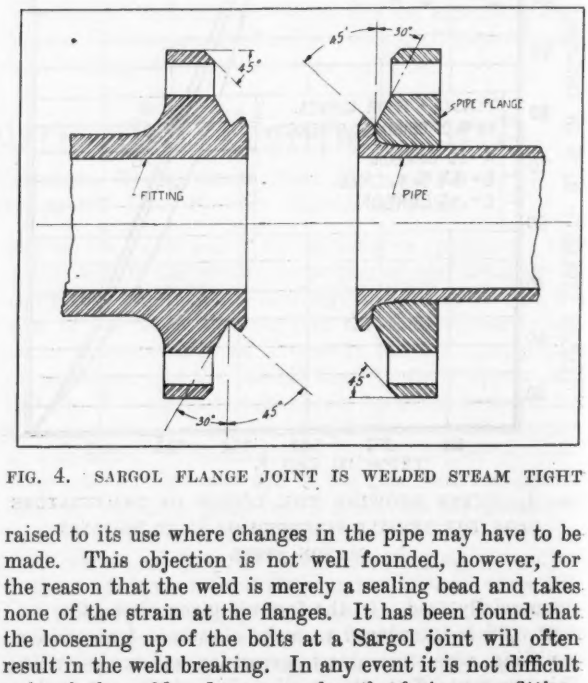


FIG. 4. SARGOL FLANGE JOINT IS WELDED STEAM TIGHT

raised to its use where changes in the pipe may have to be made. This objection is not well founded, however, for the reason that the weld is merely a sealing bead and takes none of the strain at the flanges. It has been found that the loosening up of the bolts at a Sargol joint will often result in the weld breaking. In any event it is not difficult to break the weld and remove a length of pipe or a fitting. The old welded bead should be ground or chipped away before the pipe length or fitting is placed back in the line and the joint again welded shut.

So far, practice in the use of gaskets for high temperatures and pressures tends towards the use of metal. Gaskets made of copper, a composition of 95 per cent lead and 5 per cent antimony, silver and aluminum have been tried. It has been found that all of the above metals will flow sufficiently under pressure to take up all minor defects in machining and alinement of the pipe.

Objection to the copper gasket may be made because of the danger of electrolytic action. Oxidation of the copper need not be feared because of the relatively small

surface exposed to the steam. The lead and antimony composition will not withstand temperatures in excess of 700 deg. F. Fine silver makes an ideal joint but is expensive, hence will not prove practical. Aluminum will oxidize but unless the coat of oxide is removed with a tool it does not penetrate. From present data it would appear that no great importance need be attached to electrolytic action with the use of aluminum gaskets.

Experiments have been conducted on a 36-in. flanged joint to determine the gasket pressure required for high pressures. The flange was placed under an internal pressure of 1500 lb. per sq. in. and the gasket pressure necessary to keep the joint tight was 20,000 lb. The ratio in this case was 12 to 1. It is fair to assume that this ratio is a constant one and that the pressure per square inch on the gasket should be 12 times the internal working pressure per square inch.

Careful consideration must be given to the selection of bolts for high-pressure work. The ordinary pipe work bolt will not do because it will stretch in service. It cannot be pulled up tight enough to keep the joint tight. Heat-treated steel is necessary and it is preferable that the bolt be of the double ended stud type. Chrome nickel steel of the following specifications will be found satisfactory for this service: Minimum yield point—50,000 lb. per sq. in. Minimum elongation in 2 in.—25 per cent. Minimum reduction in area in 2 in.—50 per cent.

The stress on these bolts should not be greater than 12,000 lb. per sq. in., which allows a factor of safety of four. One manufacturer recommends the bolt stress should not exceed 5000 lb. per sq. in., based on the steam working pressure acting on the area equivalent to the outside diameter of the raised face. For extremely high pressures, it will be advisable to use chrome nickel steel nuts, the nuts being cut from hexagon stock, drilled and tapped.

It will not do to assume that a valve or fitting which has ample strength at normal temperature will be equally strong under operating conditions. In fact, when the operating temperature reaches 600 deg. F. or more, the rapid deterioration of some of the alloys commonly used in the manufacture of valves and fittings is startling. For all pressures exceeding 300 lb. per sq. in. or temperatures exceeding 550 deg. F. no valves or fittings, other than steel, or of a composition whose tensile strength has been demonstrated to exceed 50,000 lb. per sq. in. with an elongation of 10 per cent in a length of 2 in. should be allowed.

Selection for valve seats and discs of a material which will give the best results is most important, when the valves are to operate under temperatures in excess of that of saturated steam. Loose seat rings are dangerous and, as temperatures increase, the difference in expansion between iron or steel and bronze becomes considerable. To overcome this difficulty, metals should be employed which expand and contract alike.

Nickel rings and rings of some nickel alloys do not loosen in steel valves, as their coefficients and the coefficient of expansion of steel are almost alike and there is no permanent expansion to be taken into account. Proper metals for valve stems are those having high strength at the highest temperatures at which they are likely to be used and a coefficient of expansion close to that of cast steel. High-grade steel fulfills these demands, as does monel metal when noncorrodibility is required.

Engineers sometimes place too much importance on the tensile or "ultimate" strength of an alloy and pay too little attention to its yield point or "elastic limit," which is a highly-important factor for the yield point in reality is the "distortion" point, i. e., the maximum stress which the material will withstand without permanent alteration of form. For illustration, after a stem in a valve begins to distort, which it does as soon as the elastic limit has been passed, it is of little further value as a stem and must be replaced.

It is not advisable to drill and tap a valve body for a drip or drain connection under the conditions of high pressure and temperature. Unequal expansion between the steel valve body and the comparatively small drain pipe results in a loosening up at the connection which will then leak. A satisfactory method of making this connection is to attach a forged angle valve to the bypass valve and then

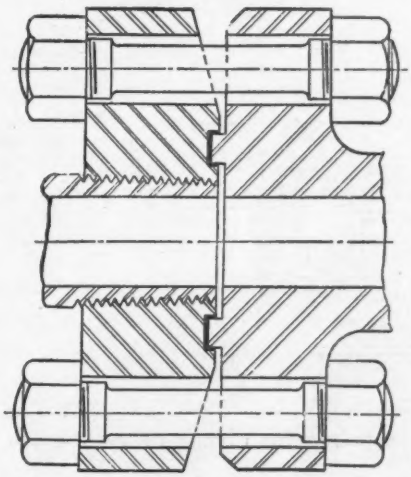


FIG. 5. TONGUE AND GROOVE TYPE OF JOINT

attach a forged straightway valve to the angle valve. These valves should be flanged and preferably ¾ in. or 1 in. in size. The angle valve is used as a master valve which permits of repairs to the second valve with the steam main in service.

Within recent years, considerable experience has been had in the construction and operation of piping systems which convey gas at 1500-lb. pressure at temperatures above 850 deg. F. For the most part these systems have been successful. They form an excellent basis for study of similar conditions to steam. They have shown; (1) that the tightness of any joint depends on the amount of pressure exerted on the gasket by the bolts under the operating conditions; (2) that the strength of all materials used should be governed by their yield point rather than their ultimate strength; (3) that ductility must not be sacrificed to obtain an extraordinarily high yield point.

THE AREA of the steam piston, multiplied by the steam pressure, gives the total amount of pressure that can be exerted. The area of the water piston, multiplied by the pressure of water per square inch, gives the resistance. A margin must be made between the power and the resistance to move the pistons at the required speed, say from 20 to 40 per cent, according to speed and other conditions.

Boiler Feed System in Sugar Refinery---I

ANALYSIS OF FEED WATER AND CONDENSATE RETURN SYSTEM IS GIVEN IN DETAIL. BY CLAUDE C. BROWN

PROPER CONTROL and regulation of the boiler feed water system is a vital and essential factor in the economic operation of any boiler plant. The equipment may be the best, the maintenance and upkeep may be of a high standard, the caliber of the operating personnel and the efficiency of operation may be high, yet with a poorly-regulated and controlled feed water supply, the maximum efficiency of plant operation cannot be obtained. The quality and regulation of the feed water pumped to the boilers has a direct bearing upon the efficiency of operation, the maintenance and upkeep cost and the life of the boiler plant equipment. The use of hard water from which the scale forming ingredients have not been entirely removed, produces a coat of scale throughout the entire feed water

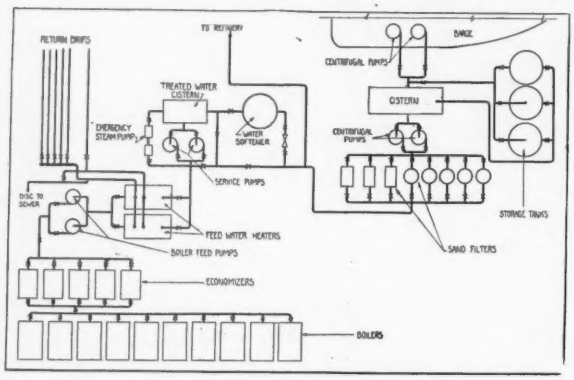


FIG. 1. DIAGRAMMATIC LAYOUT OF FEED WATER SYSTEM

system including heaters, pumps, feed lines, feed water meters, economizers and boilers, which not only restricts the area of all passages but seriously interferes with the proper functioning of the apparatus.

Cases have come to the writer's attention where it had been the custom to shut down the entire plant twice a year and completely clean out the feed-water system, this procedure being absolutely necessary to the operation of the plant, the whole condition being brought about by the improper and inefficient control, regulation and treatment of the boiler feed water. At these times of shutdown, the pump runners would have to be removed and the thick scale which covered the inner casings and the runners of the boiler feed pumps and which blocked the ports up almost completely, would have to be chipped away and scraped off. The entire inner surface of the feed-water heaters, trays, shell and outlet connections would be covered in a similar manner with a thick coating of hard scale. Six and eight-inch feed lines would be so choked up with scale that the remaining opening would not exceed three inches in diameter, while the feed branches to the individual boilers were restricted to an opening 1 in. in diameter. In the same manner the interior surfaces of the boilers and the economizers were coated with scale, with the result that the time lost and the expense incurred by the cleaning of the apparatus and the removal of tubes, burned out of the boilers and economizers through the action of the scale, were prohibitive. Such conditions as these are entirely avoidable and should never be allowed to exist in any well regulated boiler plant.

GENERAL LAYOUT OF FEED-WATER SYSTEM IN REFINERY

Just a brief description of the boiler feed-water system in a sugar refinery, the details of which will be taken up individually, will give the reader an idea of the manner in which the feed water is handled at the plant in question. The accompanying diagram illustrates the source, treatment, control and regulation of the feed water which consists of a combination of approximately 50 per cent hot return condensate from the refinery processes and 50 per cent fresh treated make-up water. These two components are mixed in two duplicate feed-water heaters and form the sum total of the boiler feed.

Cold make-up water is hauled to the refinery in barges, on which are installed motor-driven centrifugal pumps, and is pumped to a number of storage tanks and cistern where it is allowed to settle. From the tanks it flows by gravity to the cistern whence it is picked up by two centrifugal pumps and forced through a number of sand filters. From this point the greater part of the water is conducted to the sugar refinery for refining purposes and a portion is conducted to the boiler house for feed water.

That portion which goes to the boiler house is led through a water softening system to a treated water cistern located beneath the boiler house floor. From here it is picked up by two centrifugal service pumps and elevated to the top of the two feed-water heaters, being mixed here with the hot return condensate from the refinery. A steam-driven reciprocating emergency feed-water or service pump is also installed that is automatically cut into action in the case of failure of the electrically driven centrifugal service pumps.

From the heaters the feed water drops to two steam turbine driven boiler feed-water pumps, located directly beneath the feed-water heater platform. These feed pumps force the water through a venturi meter tube, to the five economizers. From the economizers the heated feed water is led to the feed-water headers over the boilers, the control of the quantity of feed water fed to each boiler is by means of a Copes continuous feed, variable level feed-water regulator.

FEED-WATER REGULATORS

During the installation of these regulators, every precaution was taken to install them correctly and carefully so that the difficulties of operation would be minimized.

Control valves which are used in connection with this type of regulator, which is a balanced type of feed-control valve, may be placed in a horizontal, vertical or an angular run of feed line, but must be so placed either above or below the thermostat, that the strut or connecting chain, which connects the valve lever and the thermostat lever, will be perfectly vertical. If this precaution is not taken, the lever connecting mechanism will bind and unsatisfactory results will be obtained.

Feed lines to the boilers in question run along the tops of the fronts of the boilers and the control valves were placed in these lines in a horizontal position directly over the water column corner of each boiler. The control valves

were securely anchored and braced so that no vibration could affect their rigidity and were so placed that the end of the control levers were directly above the thermostat levers, the thermostats being placed along the side of the boiler settings.

Each of these valves is fitted with a ¾-in. blowoff connection which is taken off at the bottom of the valve, by means of which the valves are blown off at intervals of from three to ten days depending upon the condition of the feed water. It has been found in practice that this is an important factor in the successful operation of this apparatus. Another feature that merits considerable attention is the proper oiling and cleaning of these valves. Care should be taken to keep the packing properly fitted, just tight enough but not binding. It has been found to be excellent practice to have the water tender work each of these valves by hand once during each watch thereby insuring himself that all of the valves are free and do not stick.

All of these control valves were installed in accordance with the direction of the arrow cast on the side of the valve body, full advantage being taken of the blowoff arrangement. All were placed in an upright position so that the counter weights operated to close them.

Each of these valves is thoroughly overhauled and cleaned every 90 days during the overhauling and cleaning of the boiler which it serves. At these times the valve is taken apart, the packing examined and if necessary renewed, the stem and discs removed, cleaned and, if necessary, reground and the entire interior of the valve scraped and cleaned.

Thermostats were installed on the side of each boiler near the front, in such position that the end of the thermostat levers were directly underneath the ends of the levers actuating the control valves. The thermostats were installed on angle iron brackets securely bolted to the boiler settings so that the whole arrangement was rigid in every respect. Extra holes were placed in the supporting brackets so that either end might be lowered or raised slightly.

These thermostats were so placed that the upper end of the expansion tube was exactly level with the highest permissible water level, this point being about ¾ in. from the top of the glass and the lower end exactly level with the lowest permissible water level, ¾ in. from the bottom of the glass, the whole being so placed that the expansion of the operating element tended to open the control valve.

Connections were then made to the steam drum of the boiler, the steam connection at the top of the drum head and the water connection to the bottom of the same drum head. Connections were not made to the top and bottom of the water column, as is often done, for the reason that it was felt that the limits of water level were so wide that trouble might be encountered in obtaining dry steam for the steam connection to the expansion tube. It was also felt that the blowing off of the water column would have a disturbing effect upon the feed-water regulation.

The steam connection was then made of ¾-in. pipe, lagged and insulated by the shortest route from the top of the expansion tube of the thermostat to the top of the drum head. No elbows were used in this connection, pipe bends being substituted. Great care was taken to eliminate all pockets and traps in the piping, and the line was drained back to the boiler, with a drop in excess of 1-in. per ft. A gate valve was installed in this line near the boiler drum head in each case. The lower end of the expansion tube was then connected to the bottom of the same drum head by means of a ¾-in. uncovered line. Here again great care was taken to avoid pockets and traps and a gate valve was placed in the line at a point near the drum head.

At the time of installation each regulator was adjusted at normal boiler load. This was done by slacking off several turns on the nuts of the tension rods. Then with the gate valve in the steam line closed, the valve in the water line was opened and the regulator tube filled with water. The water valve was then closed. The steam valve and the blowoff valve were then opened and the regulator was allowed to blow down for about two minutes. The blowoff valve was then closed and the water valve opened. After a period of some 20 min. when the temperature of the regulator had become normal, the regulator was then adjusted by means of the nuts on the tension rod so that the lever arm of the thermostat was about horizontal. The hand feed check was then opened wide and the regulator allowed to take full control. If it was found that the water input to the boiler was too great, the adjusting nuts on the thermostat were slacked off so as to close the control valve slightly. If the water input was found to be insufficient, the opposite adjustment was made.

Shortly after the installation of the regulators at this plant some trouble was experienced in making them operate properly. There appeared to be a lag or sluggishness in their operation. Upon investigation it was found that the steam that was supplied to the upper ends of the regulator expansion tubes was not sufficiently dry at all times to expand the tubes properly. Although the connections for steam were made at the top of the drum heads, the wide variation in load and water levels at times resulted in wet steam being supplied to the regulators. As a result of this investigation, changes were made so that the steam connections were taken off the boilers at the safety valve nozzles after which no further trouble with wet steam was encountered.

At this plant the boilers are operated at loads varying from 50 to 200 per cent of rating, the steam demands being at times sudden and variable. The reason for this greatly varying load is that the steam from the boilers is used in vacuum pans for the purpose of boiling sugar and when one of these pans is put on, the maximum steam demand occurs in the first few minutes of operation of the pan. It is thus necessary to maintain a widely varying range of water levels in the boilers. When a pan is put on, the sudden increase in load causes the steam pressure to drop and this in turn allows the water level in the boiler and in the expansion tube, to rise. Due to radiation, the water in the tube has a much lower temperature than the steam, and a rise in water level therefore means a contraction of the tube. This in turn means a decrease in the control valve opening and a decrease in feed. A decrease in feed together with a lowering of the boiling point of the boiler water caused by the decrease in pressure, means a substantial increase in the rate of steaming at the time that that increase is required.

This increased rate of steaming then quickly evaporates a considerable amount of water and the level in the tube falls below the center. This in turn causes more of the tube to expand and the control valve opening increases correspondingly. If the load increases again, the steam output is again increased and the water level drops still lower. This will continue only until the lowest desired water level has been reached. If the overload remains constant, the regulator will automatically maintain the water level con-

stant and at the point which insures maximum efficiency for that particular load. On decreasing loads the regulator automatically raises the water level until the highest desired level has been reached.

It is essential that the expansion tubes of these regulators be blown out periodically, if the feed water is dirty, for the reason that mud or sediment tends to collect in them. In a like manner, if the lines to the tubes contain traps or pockets, the tubes are likely to become air or vapor-bound. Both mud and air prevent the apparatus from functioning properly in that they prevent the heat from the steam from reaching the metal of the tube. In order to clear the tube of mud the steam valve should be closed and the tube blown down with water. In order to clear the tube of air, the water valve should be closed and the tube blown down with steam.

Hot Return Condensate

Hot return condensate returned to the boiler house from the refinery, is delivered to the two duplicate feed-water heaters through a number of separate lines, experience having shown that satisfactory results are obtained only when hot water returns from apparatus under the same pressure are confined to the same return line. Several attempts were made to reduce the number of return lines by combining the returns from a group of steam-using equipment of different character, for instance vacuum pans, heating coils, and steam traps but the attempts met with little success for the reason that only a portion of the apparatus so connected would be properly drained, the remainder being unable to get rid of the condensate.

Every precaution should be taken in the construction of hot water return lines, to eliminate all pockets, vertical U-bends, inclines or other vapor or air traps in which air or non-condensible gases will collect and restrict the flow. In an 8-in. return line from the refinery to the boiler house which conveyed only the hot condensate from the 60-lb. steam coils of four 14-ft. vacuum pans, the distance being approximately 200 ft., of which 150 ft. was vertical, a great deal of trouble was experienced with the line becoming vapor-bound. There was no pressure on the line other than the static pressure of the water, inasmuch as the 60-lb. coils of the pans were drained by a battery of 52 steam traps, which discharged into a common 6-in. header on the seventh floor of the refinery. This header discharged into the 8-in. return line which followed down along the wall of the refinery. This line, containing a few turns, entered the boiler house along the lower members of the roof trusses, crossed over to the far side of the boiler house and dropped directly into the manifold of the duplicate open type feed-water heaters.

After several cases of trouble with this line becoming vapor bound, it was thoroughly gone over and a number of the vapor traps removed. It was also found that the portion of the line that crossed the boiler house had been installed with a rise in the horizontal rather than a drop, resulting in an air or vapor pocket at the elbow or bend above the heater. This work resulted in a decided improvement in the operation of the line.

Another source of trouble that was encountered in this and other return lines was the fact that they would become vapor bound in the manifolds into which the steam traps discharged. This was due to the fact that the hot condensate from the 60-lb. steam coils would flash back into steam as soon as it was discharged from the traps at 60-lb. pressure, into the discharge header at approximately atmospheric pressure. This difficulty was overcome by installing an expansion drum in the return line, near the point where it connected with the trap discharge manifold, and venting this drum (which was 36 in. in diameter by 6 ft. long) with a 2-in. line, the latter being carried to the refinery hot water tanks.

Another factor in the successful operation of hot water return lines is the minimizing of line friction through the use of long radius bends instead of elbow fittings, and long sweep tees instead of standard tee castings and in keeping runs as straight as possible with a minimum number of valves and fittings in the line.

Considerable difficulty was experienced with the steam traps blowing through and the valve points becoming scored and corroded. This difficulty was overcome by replacing the brass and bronze valve points and also the valve seats with monel metal.

Directly over one end of the feed-water heaters is a 12-in. manifold which discharges to either one or both of the heaters, and into which are connected all of the hot water returns from the refinery. The lines connected to this manifold include:

One 8-in. line from 60-lb. coils of vacuum pans (traps).

One 8-in. line from 15-lb. exhaust steam coils of vacuum pans (traps).

One 8-in. line from 15-lb. U-tube, 15-lb. vacuum pans (no traps).

One 6-in. line from 15-lb. heating coils in liquor tanks. This line is of the U-tube design. (No traps.)

One 4-in. line from 60-lb. coils of small vacuum pan (traps).

One 3-in. line from traps on 15-lb. exhaust header.

One 2-in. line from miscellaneous 15-lb. exhaust piping (traps).

One 1¼-in. line from miscellaneous 100-lb. traps.

Two 1-in. lines from various 100-lb. traps.

The average quantity of returns delivered to the boiler house feed-water heaters through these return lines is 150,000 lb. per hr., the quantity fluctuating of course with the steam demand.

On each of the return lines from the vacuum pans or from the heating coils in the syrup or liquor lines there is a connection to an overboard line to the sewer so that in case there is any appreciable amount of sugar contained in the returns it may be temporarily discarded to the sewer. These returns are tested regularly every half hour for the purpose of detecting sugar. This is a most important factor in the regulation of the boiler feed water for the reason that any appreciable quantity of sugar in the feed water corrodes the economizers and boilers.

The U-tube design of return lines, which operate directly from the apparatus drained without the use of steam traps, are used only in connection with apparatus operating on exhaust steam pressure, that is, from 10 to 15 lb. pressure. The principle and its adaptation for the purpose of returning condensate without the use of steam traps is novel. Each U-tube system consists of a number of discharge lines from the coils of the 15-lb. steam apparatus which are dropped from the seventh or sixth floors of the refinery to the ground floor where they connect to a 6-in. manifold, each fitted with a gate valve at the manifold connection. A 6-in. discharge line is then carried back up from this manifold to the level of the boiler feed-water heaters and a long radius bend carries the line through

the wall into and across the boiler house, dropping to the heater manifold. The U-tube effect of this arrangement affords sufficient head to counter-balance the 15-lb. exhaust steam pressure on the apparatus side of the tube so that the condensate continues down around the lower bend of the tube, rises up the discharge side of the tube and is delivered over across the boiler house and into the heater without the use of steam traps.

The number of vacuum pans and other steam using apparatus and the diversity of their operation is such that the return condensate is delivered to the boiler house feedwater heater in a fairly even flow, the amount returned varying almost in direct proportion to the rate of generation of steam, which factor, of course, determines the feed water demand.

While there are 6000 kw. rated capacity of steam turbines now installed in this plant, they furnish no return condensate to the boiler house for the reason that they are operated non-condensing and discharge into the exhaust steam system against a back pressure of from 10 to 15 lb. The exhaust steam thus produced together with the exhaust of turbines, pumps and other steam prime movers, is utilized for the heating and evaporating of sugar liquors, syrups and sweet waters, and the fact that only 50 per cent of it is returned to the boiler house as condensate is due to the practice of heating the water and liquors in the refinery by directly injecting the steam into the body of the liquid, the condensate being ultimately lost in the salt cooling water of the barometric condensers when the liquors are evaporated to crystalline sugar.

In the reader's mind the question may arise why the hot condensate from the various pans, heating tanks, etc., is not returned directly to the boilers through the medium of direct return traps. In this connection it may be said that this was tried out, when the present head engineer installed a battery of direct return traps on the vacuum pans at an investment of some $40,000. The experiment was a failure for the reason that either through ignorance of the characteristics of this type of apparatus, or through poor judgment, the installation was poorly made and insufficient head room was allowed between the traps and the boilers.

Part II, which will conclude the series, will take up such items as fresh water make-up, storage systems, filters and softeners, and feed water testing.

Thrift Builds a Foundation for Character

THE HABIT OF ECONOMY IN MONEY MATTERS INDUCES ORGANIZATION OF ACTIVITIES AND A SPIRIT OF SELF-RELIANCE. BY SAMUEL INSULL

IN AN address delivered in Chicago during Thrift Week, Mr. Insull emphasized the value of thrift, not only in providing against future needs, but as a character builder in every direction. The following is made up of extracts from the address which is so full of sound sense as to the values in life that it is worth reproducing.

Herbert Spencer has said that we are creatures of habit. We succeed or fail as we acquire good or bad habits and we can acquire good habits just as easily as we acquire bad ones. Most people do not believe this; only those who find it out succeed in life.

Samuel Smiles said that thrift began with civilization but I think that it began before that, for I think that Mr. Squirrel and those of his kind, who, when nuts are plentiful in the fall, put away a store for use in the winter, were thrifty long before modern civilization began. Human thrift began as soon as men realized that it was necessary to provide for tomorrow as well as for today. It means private economy as well as the orderly management of a family.

I well remember, now upwards of half a century ago, saving my first money to buy a birthday present for my mother. It was my first lesson in thrift, for it is just as thrifty a thing to make sacrifices and save money to do something for your own people as it is to save money and put it away to do something for yourself. Effort at saving means self denial. It means self discipline. It is the start of a boy or girl or a man or woman towards self reliance and the goal of being independent of others. It assists in the formation of character and the making of a good citizen.

Andrew Carnegie said: "The man who does not and cannot save money, cannot and will not do anything worth while." I think that is a good sentiment. And John Wanamaker said: "No boy ever became great as a man who did not, in his youth, learn to save." Again, in one of his essays, William Gladstone said: "Economy is near to the keystone of character and success. The man who saves will rise in his trade or his profession steadily. This is inevitable."

Habits of thrift in money matters must, inevitably, tend towards economy in other directions; economy of time, concentration of thought, habits of organizing one's self, so to speak, coordinating one's efforts and developing and broadening the mind.

While the direct practice of thrift is desirable in itself and leads, as you accumulate, to a sense of independence, still I think that the resultant things that naturally occur with the thrifty man or woman are of infinitely more consequence to him and of much greater value to the community than the saving of the money. Self reliance and independence in financial matters must result in reliance and confidence in one's self in other matters, which must lead a man toward taking a much broader view of life and arouse in him a greater desire for achievement. Mr. Wanamaker has said: "The difference between the man who spends all his salary and the man who saves a part of it is the difference, in ten years, between the owner of a business and the man out of a job."

Many people disparage thrift. They usually end by being on their uppers and trying to "work a touch" on you when they meet you on the street. They call thrift meanness and miserliness and argue that "money should be kept in circulation." But their vision is limited and is warped by their own extravagance.

Thrift fits you better to serve the community that gives you protection and to which you owe a service. It makes a better citizen of the man who, by his savings, has acquired some ownership of property and the sense of responsibility that ownership of property, be it ever so small, brings. Then see what thrift has done for our own country and every other country. The accumulations of capital resulting from thrift, combined with the brains and brawn of our citizens, have annihilated time and space, have given us our vast railway systems, our overseas transport, our submarine cable system, our telegraph and telephone systems and released our great natural resources for the use of mankind.

Power Plant Design and Operating Cost---II

COMPARISON OF COSTS USING VARIOUS PRIME MOVERS WHICH ARE TO OPERATE NON-CONDENSING AND WHICH WILL USE SUPERHEATED STEAM

REPORT OF THE design and maintenance of a 1500-kw. central station the prime movers of which were to use superheated steam and be provided with condensing equipment was given in the April 1 issue of Power Plant Engineering. That report and the data given herein was taken from the report of the prime movers committee of the N. E. L. A. The data given in this second installment covers the investment and operating costs of a 1500-kw. central station which is operated non-condensing and with superheat.

As in the previous problem, the location of the plant is assumed to be near an adequate supply of water which in this case need only be suitable for boiler feed purposes. A railroad siding is assumed to be provided in order that coal may be delivered to the plant. The costs covering the installation of the Diesel type of prime mover are not given for comparison with the non-condensing plant for the reason that those costs are more nearly comparable with the steam plant which is run condensing.

Building construction is assumed to be of steel frame with brick walls. The construction costs are again based on the price of material and labor which held in the vicinity of Philadelphia in February, 1923. All plants have been laid out with four 500-kw. generating units and ample boiler capacity is provided for carrying a peak load when one generating and one boiler unit are out of service. Electric current is to be generated at 2300 v., 3-phase and 60 cycles. The operating costs have been assumed on the basis of three load factors; namely, 25, 50 and 75 per cent.

By referring to the table on the opposite page, it will be noted the comparison for the non-condensing plants is based primarily on the type of prime mover to be used. The units used are the turbine, uniflow engine, simple four-valve engine, compound four-valve engine, simple Corliss and the compound Corliss engine. Steam pressures at the throttle have been assumed as follows: turbines 200 lb. gage, uniflow engine 175 lb., simple and compound Corliss engines 150 lb. and the four-valve engines 175 lb. The back pressure in all cases is taken at atmospheric pressure.

Superheat is assumed at 150 deg. F. for the turbines, 150 deg. F. for the uniflow engines, 100 deg. F. for the simple and compound Corliss engines and 100 deg. F. for the simple and compound four-valve engines. Boiler plants have been laid out to operate at maximum efficiency at 175 per cent of normal rating. All boiler plants are stoker fired and are capable of operating at 250 per cent of rating for a period of not less than 2 hr. Boiler efficiencies have been assumed as follows: 65 per cent at a load factor of 25 per cent, 70 per cent at a load factor of 50 per cent and 73 per cent at a load factor of 75 per cent. All coal is assumed to cost $7 per T. delivered at the plant and the heating value of the coal is assumed at 13,500 B.t.u.

Labor cost for operation is based on the following figures:

Class of Employe	Turbine and steam engine plants load factor 25%	50% and over	Salary per month
Chief Engineer	1	1	$225
Watch Engineer	2	2	150
Asst. Engineer	0	0	125
Firemen	3	3	125
Laborers	1	2	90

Figures covering maintenance are based on data from similar plants which are in actual operation. Annual fixed charges are assumed at 15 per cent for all plants. This latter point may readily lead to some discussion, however, it serves to place all units on a comparable basis. The curves given in Figs. 1, 2 and 3 show the average economy guarantees made for each of the various prime movers. The steam consumption for the turbine plant represents the mean figures of five manufacturers. The corre-

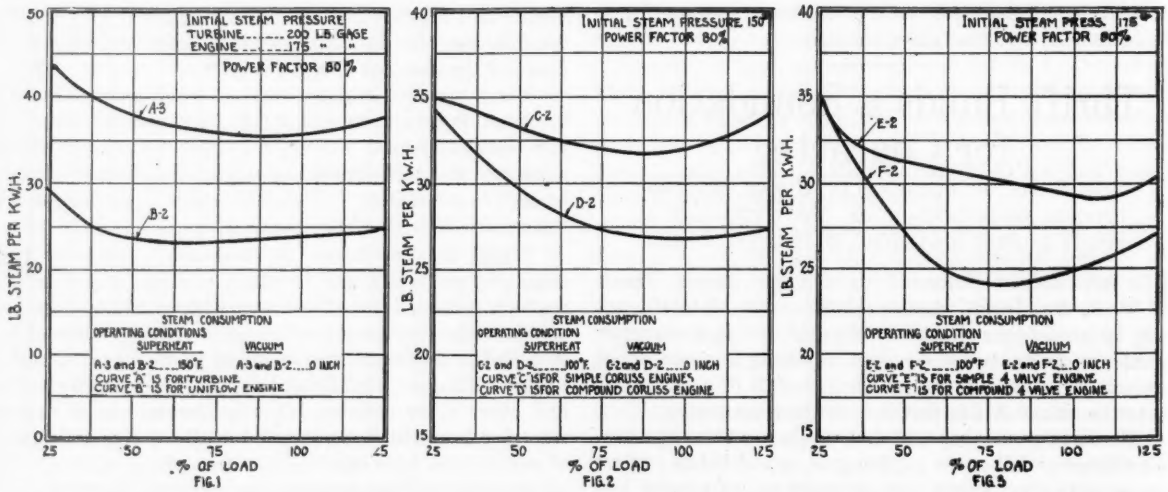


FIG. 1. AVERAGE STEAM CONSUMPTION OF A TURBINE AND A UNIFLOW STEAM ENGINE. FIG. 2. AVERAGE STEAM CONSUMPTION CURVES FOR SIMPLE AND COMPOUND CORLISS ENGINES. FIG. 3. AVERAGE STEAM CONSUMPTION CURVES FOR SIMPLE AND COMPOUND VALVE ENGINES

sponding figures for the uniflow engines represent the mean figures of six builders. The Corliss engine curves were worked up from the mean figures of four builders. Three builders are represented in the curves for the simple four-valve engine and but one builder is represented in the steam consumption curves for the compound four-valve engine.

Study of the table, which shows investment and operating cost indicates that at 50 per cent load factor the operating cost per kilowatt-hour is highest for the turbine plant and at the same time the investment cost of the turbine plant is the lowest. It will also be noticed that the operating costs are lowest for the compound four-valve engine and that the highest installation cost is incurred by the compound Corliss engine plant.

Investment and operating costs for 1500 kw. central stations operating non-condensing and without superheat will be given in the May 1 issue.

Investment and Operating Costs of a 1500-kw. Central Station Non-Condensing Plant with Superheat

INVESTMENT COSTS

	Turbine Plant	Uniflow Engine Plant	Simple Four Valve Engine Plant	Compound Four Valve Engine Plant	Simple Corliss Engine Plant	Compound Corliss Engine Plant
Real Estate	$8,000.00	$8,000.00	$8,000.00	$8,000.00	$8,000.00	$8,000.00
Building	141,300.00	177,200.00	161,500.00	150,000.00	151,000.00	159,300.00
Boilers	58,600.00	44,200.00	53,900.00	46,300.00	52,400.00	47,500.00
Stokers	19,700.00	14,350.00	15,800.00	13,600.00	15,800.00	14,350.00
Piping	45,000.00	45,000.00	45,000.00	45,000.00	45,000.00	45,000.00
Generating Units	73,500.00	135,700.00	131,500.00	142,500.00	131,500.00	158,500.00
Switchboard	17,600.00	17,600.00	17,600.00	17,600.00	17,600.00	17,600.00
Wiring	13,200.00	13,200.00	13,200.00	13,200.00	13,200.00	13,200.00
Chimney and Flue	18,000.00	18,000.00	18,000.00	18,000.00	18,000.00	18,000.00
Forced Draft Fans and Ducts	7,800.00	6,500.00	6,800.00	6,500.00	6,800.00	6,500.00
Coal and Ash Handling Equipment	35,250.00	35,250.00	35,250.00	35,250.00	35,250.00	35,250.00
Engine Room Crane	2,100.00	2,550.00	2,400.00	2,400.00	2,550.00	2,550.00
Feed Water Heater	3,000.00	2,500.00	2,700.00	2,500.00	2,700.00	2,500.00
Feed Pumps	4,800.00	4,300.00	4,500.00	4,010.00	4,500.00	4,300.00
Equipment Foundations	6,620.00	15,300.00	11,670.00	15,830.00	11,870.00	13,900.00
Oil Filters and Tanks	2,500.00	2,500.00	2,500.00	2,500.00	2,500.00	2,500.00
Railroad Siding	2,550.00	2,550.00	2,550.00	2,550.00	2,550.00	2,550.00
Total	$459,520.00	$545,200.00	$532,870.00	$525,740.00	$521,220.00	$551,500.00
Cost per kw. (1500 kw. Peak)	$306.35	$363.47	$355.25	$350.49	$347.48	$367.67

OPERATING COSTS

Load Factor 25%

Fuel	$87,500.00	$60,900.00	$67,550.00	$63,000.00	$69,825.00	$61,600.00
Labor	11,580.00	11,580.00	11,580.00	11,580.00	11,580.00	11,580.00
Lubricants	250.00	500.00	500.00	500.00	500.00	500.00
Supplies	3,200.00	3,400.00	3,500.00	3,400.00	3,600.00	3,400.00
Operation (Total)	$102,530.00	$76,380.00	$83,130.00	$78,480.00	$85,505.00	$77,080.00
Maintenance	6,700.00	8,000.00	7,500.00	7,500.00	7,500.00	7,500.00
Production (Total)	$109,230.00	$84,380.00	$90,630.00	$85,980.00	$93,005.00	$84,580.00
Fixed Charges 15%	68,928.00	81,780.00	79,931.00	78,861.00	78,183.00	82,725.00
Total Cost at Bus	$178,158.00	$166,160.00	$170,561.00	$164,841.00	$171,188.00	$167,305.00
Cost per kw-hr.						
Production	$0.0333	$0.0257	$0.0276	$0.0262	$0.0283	$0.0258
Fixed Charges	0.0210	0.0249	0.0243	0.0240	0.0238	0.0252
Total	$0.0543	$0.0506	$0.0519	$0.0502	$0.0521	$0.0510

Load Factor 50%

Fuel	$133,350.00	$93,800.00	$110,250.00	$95,725.00	$113,400.00	$98,350.00
Labor	12,260.00	12,660.00	12,660.00	12,660.00	12,660.00	12,660.00
Lubricants	300.00	550.00	550.00	550.00	550.00	550.00
Supplies	3,400.00	3,600.00	3,700.00	3,600.00	3,800.00	3,600.00
Operation (Total)	$149,310.00	$110,610.00	$127,160.00	$112,535.00	$130,410.00	$115,160.00
Maintenance	9,300.00	10,000.00	9,500.00	9,500.00	9,500.00	9,500.00
Production (Total)	$158,610.00	$120,610.00	$136,660.00	$122,035.00	$139,910.00	$124,660.00
Fixed Charges 15%	68,928.00	81,780.00	79,931.00	78,861.00	78,183.00	82,725.00
Total Cost at Bus	$227,538.00	$202,390.00	$216,591.00	$200,896.00	$218,093.00	$207,385.00
Cost per kw-hr.						
Production	$0.0241	$0.0184	$0.0208	$0.0186	$0.0213	$0.0190
Fixed Charges	0.0105	0.0124	0.0122	0.0120	0.0119	0.0126
Total	$0.0346	$0.0308	$0.0330	$0.0306	$0.0332	$0.0316

Load Factor 75%

Fuel	$168,000.00	$117,950.00	$137,200.00	$121,450.00	$145,075.00	$121,450.00
Labor	12,260.00	12,660.00	12,660.00	12,660.00	12,660.00	12,660.00
Lubricants	350.00	600.00	600.00	600.00	600.00	600.00
Supplies	3,600.00	3,800.00	3,900.00	3,800.00	4,000.00	3,800.00
Operation (Total)	$184,210.00	$135,010.00	$154,360.00	$138,510.00	$162,335.00	$138,510.00
Maintenance	10,250.00	11,000.00	11,000.00	10,500.00	10,500.00	10,500.00
Production (Total)	$194,460.00	$146,010.00	$165,360.00	$149,010.00	$172,835.00	$149,010.00
Fixed Charges 15%	68,928.00	81,780.00	79,931.00	78,861.00	78,183.00	82,725.00
Total Cost at Bus	$263,388.00	$227,790.00	$245,291.00	$227,871.00	$251,018.00	$231,735.00
Cost per kw-hr.						
Production	$0.01970	$0.01505	$0.01679	$0.01510	$0.01756	$0.01510
Fixed Charges	0.00700	0.00805	0.00811	0.00800	0.00794	0.00840
Total	$0.0267	$0.0231	$0.0249	$0.0231	$0.0255	$0.0235

Small Plants Need Engineers' Attention

By W. J. Rheinfrank*

WITH THE passing of the old year came the statistician, who told us that last year's growth and development stands out as an epoch in the production of power. It is estimated that the electrical energy developed was increased 15 per cent over the previous year. Also that the industry has increased more during the last 6 yr. than during the previous 36 yr. But under pressure of the present momentum, it behooves us to pause for reflection and analysis of certain phases of the industry, particularly the isolated central station of medium size and many industrial power plants.

Industrial and Super-Station Power Plants

In this era of high pressures and temperatures, and the development of super-units, in the quest for higher efficiencies, the engineering talent of the country has been concentrated on the larger central stations. While ultimately many smaller central stations will be abandoned in favor of the super-station, this process will be gradual. Also many power plants in connection with our industrial works must continue to exist, to furnish heat, power, and process steam. It has been estimated that the bulk of power consumed by plants of the latter group, is not produced by the larger central stations. Also that 75 per cent of the cost of the production of power is in the boiler room. It is there that the greatest increase in efficiency is possible. Hence this appeal to the engineering world for serious consideration of the condition of the smaller central stations and the industrial power plants, to aid in the conservation of our fuel supply, as well as the reduction of production costs of all commodities.

Gradual Raising of Standards

Rapid strides have been made during the past 10 yr. by the larger central stations, in the development of boiler plant equipment. This has been accomplished by the installation of water meters, coal scales, flow meter, CO_2 recorders, pyrometers, draft gages, combustion control equipment, etc., by properly maintaining these instruments, and by careful study of the records obtained. This process of analysis has caused a gradual raising of standards of comparison, necessitating much development work and many changes in design of boilers, stokers, etc., to enable them to meet the new standards.

Working in the Dark

Smaller central stations and industrial plants have also replaced return tubular boilers with water-tube boilers, and hand-fired grates with mechanical stokers. By virtue of the principles involved, cheaper power has been produced. In some plants water meters, coal scales, etc., have been installed. In many no instruments other than draft gages are to be found, and these are often inaccurate. The change to modern equipment made possible an increase of from 15 to 20 per cent in efficiency, yet rarely is this total possibility realized:

In many plants the amount of the increase is not known because of an additional load increase, coincidental with the rebuilding of the plant, making the use of even the remote and inaccurate comparison of the cost of coal per year, impossible. Operating engineers are working in the dark; having no means of gaging their results, they have but one objective, to keep up steam.

More Consideration For Industrial Plants

When considering the prominence which the increase in efficiency in the production of power has attained, it is hard to understand why these conditions still exist in central stations where the business is solely one of manufacturing kilowatts. There, 75 per cent of the cost of the ultimate product is in the boiler room. As this does not hold for industries where the ultimate product is paper, steel, glass or what-not, more consideration must be given to the latter class. Many manufacturers are not power engineers. Being specialists in the manufacture of a product other than kilowatts, all processes involved in the manufacture of that product are made as efficient as possible. The power plant is a necessary evil. It is a strange field, and interest lags. Modern boilers and stokers are installed, but the job is not finished. If gages and instruments are installed, often provision for the proper care and maintenance of them is not made. Very soon they are either inaccurate or entirely inoperative. Perhaps the coal is weighed and the water measured, but the coal is not analyzed. Many operators do not know from what mines or section of the country the coal is obtained. Likewise an analysis of the ash is seldom made. Flue gas temperatures are not recorded. Flue gases are not analyzed. The operating engineer does the best he can, not knowing where his greatest losses occur, or how to reduce them.

Coal Pile Is Cash Drawer

The coal pile is analogous to the cash drawer. While desiring to lower production costs, many manufacturers of kilowatts and commodities have overlooked the most important factor involved in the process, the human element. High-class engineers, capable of increasing the combined efficiencies, are placed in charge of these plants. The desire to excel is a human instinct. If deprived of standards of comparison, this instinct is blighted. If expected only to produce power, the objective is lost. If allowed to try to produce power more efficiently than the other fellow, a saving of coal is a natural consequence, and production costs are lowered. There is but one answer. Provide the operating engineer with the proper scales, meters, gages, and instruments, to enable him to determine his plant's efficiency. Also provide instruments to enable him to compute his losses so that he can reduce the aggregate of these losses to a minimum.

Developing the Art

Only a part of the total effort being concentrated upon the super-station to obtain a gain of 2 or 3 per cent, would, if properly directed, obtain a mean gain of from 10 to 15 per cent in many smaller central stations and power plants. The combined knowledge of the consulting engineers, the manufacturers of power plant equipment and the operating engineers, together with more publicity, if placed at the disposal of the men who pay for the coal, should tend to place these plants more nearly on a par with the super-stations, and to make for an all-around, balanced development of the art of the production of power.

*District Stoker Engineer, Westinghouse Electric & Manufacturing Co.

Thin Joints and Durable Furnace Walls

By Hugh Weightman

AT THE present moment in the progress of boiler furnace building, we find some advocates of thick joints. The reason most often given for the thick joint is that of variation in brick dimensions. The principal dimension involved in setting brick is the thickness of the brick. The specifications for No. 1 brick allow a maximum dimension of 2¼ in. and a minimum dimension of $2\frac{1}{16}$ in.—a variation of $\frac{3}{16}$ in. The thick joint advocates at this point make an error in assuming this maximum variation as occurring. As a matter of fact, shipments of brick are far under this variation, some manufacturers working close to one limit and others working to the other limit. An investigation of the product of most of the recognized large manufacturers of fire brick shows them to be most uniform and working near the upper limit with a variation in brick thickness of $\frac{1}{16}$ in. as a maximum. As a consequence of the close limits used the thick joint is not warranted on this score.

Requirements of a good bonded brick joint are mechanical strength and stability under continued heating. Should fusion of the material take place, the joint as a rule will fail, either by chemical action between the brick and jointing material or settling of the wall. Either case will cause the failure of the wall. More often, however, the jointing material will soften and then flow, even at temperatures much lower than the actual fusion temperature of the material at atmospheric pressure, without mechanical load. This factor becomes at once more important than the usual fusion temperature as recorded by the cone test.

In the manufacture of some special cements for setting brick, use is made of materials of differing specific gravity. If the materials so used were miscible in each other, it is possible so to dilute the mortar that thin joints are possible. If such materials have a component incapable of solution in the others, it is necessary to employ such mortars as a very thick paste; under such conditions thick joints are necessary to the employment of the materials, regardless of the fact that such joints may be unstable mechanically.

When stiff mortar is employed in the jointing of brick there is no penetration of the mortar into the brick. As a consequence, the joint consists of merely a bedding material between the brick. If such material was as stable as the brick, no harm would result but shrinkage of the mortar causes a failure of the wall. As there is little, if any, actual bond action between the brick and mortar, a brick to brick joint is preferable to the use of thick mortars.

In the ideal joint, the brick are cemented together by the intimate penetration of the bonding material into the brick. As the pores of the brick are of the order of 0.2 to 0.4 microns (1 micron equals 0.001 millimeters) nothing short of a very fine bonding material can penetrate these pores. The water used in mortars may penetrate but the particles of the bonding mortar do not, unless such material is of nearly colloidal proportions. The requirement for such bonding mortar, then, is a part of the material of colloidal proportions for penetration and a heavier part of just sufficient solidity to make a thin bed for taking care of difference in dimensions of the brick.

In the study of clay bonding, it is found that, to insure the maximum mechanical strength throughout the entire time from the assembly of the wall to the completion of burning, it is necessary to cause the maximum shrinkage to take place and this shrinkage must take place before cone 8 has fallen. Cone 8 is approximately 1290 deg. C. (2354 deg. F.). With the usual fire clays, the shrinkage takes place early but there is an absence of bonding power until after the clay has melted. With many preparations on the market such shrinkage does not take place and in some instances attempts have been made to prevent such shrinkage in the belief that this would render the thick joint more stable. The amount of shrinkage expressed as a fraction of the original volume will vary with different materials, being more or less, dependent upon the structure of the clay.

In conclusion it may be stated that thin joints have always found favor in practice, based on their success in service. This is especially true of the furnaces used in industrial service. The use of thin joints are further recommended by "Steam" published by the Babcock & Wilcox Co., and will be found recommended by many of the standard authorities on boiler furnace practice.

One further point in regard to brick-setting mortars is the setting quality regardless of the thickness of the joints. It is desirable that the mortar set hard all the way through the wall. In some compounds for this purpose the materials are taken so as to produce what is termed a cold set. Such "cold-set" material while setting hard in air is still soluble in water. For this reason it must be fired before taking a permanent set. At points remote from the furnace interior the temperature rise is just enough to render such bonds powdery and without any setting quality. A bond, to be of service, need not set hard in air but it must set hard when raised to a point above the boiling point of water. As a rule, materials setting below this point are not hard set above this temperature, except when fired to the melting point of the material.

No material should be used that in service forms a glassy structure at the furnace interior. The structure should be stony and hard but the presence of shiny glass particles should be avoided.

On Jan. 1, 1924, consumers of soft coal had on hand approximately 62,000,000 T. of that fuel. The year just passed was one of practically uninterrupted accumulation of reserve stocks, and the inventory at its close revealed the following facts: Stocks on Jan. 1, 1924, were 2,000,000 T. larger than on Oct. 1, 1923, and about 6,000,000 T. larger than on Sept. 1. In comparison with corresponding dates of preceding year, stocks on Jan. 1, 1924, were 72 per cent larger than in 1923, 29 per cent larger than in 1922, 35 per cent larger than in 1921, and even exceed those on Jan. 1, 1919, by 7 per cent. In fact on only two dates for which stock records are available has the present supply been exceeded—Armistice Day, 1918, and April 1, 1922.

Measured in terms of tons, stocks increased 3.3 per cent during the last quarter of 1923. Measured in terms of days' supply, the increase was 2.2 per cent. These percentages are based on averages which assume that the supply was evenly distributed. Stocks are never evenly divided, however, and the use of such averages is proper only for the purpose of comparison. There are those in every community who carry stocks much larger than the average and those who habitually carry very small or even no reserve stocks.

Hydraulic Turbine Efficiency

Method of Conducting Efficiency Tests Are Described. By F. Johnstone-Taylor

IN CONNECTION with the recently completed hydro-electric station at Raanaafoss, Norway, where six large double wheel turbines are installed, each developing 14,000 hp. on a fall of 43 ft. 4 in., the measurement of the water during the tests was the subject of the most careful consideration. As the head is comparatively low, extreme care had to be taken to determine the working head with the utmost accuracy while the large volumes being dealt with necessitated some special measuring arrangements.

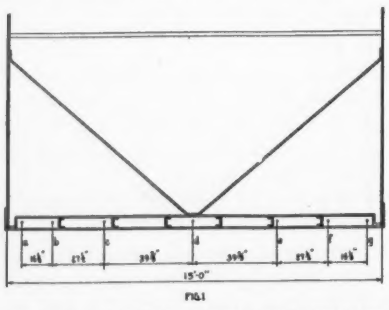


FIG. 1. ARRANGEMENT OF MOVABLE CURRENT METER FRAMES

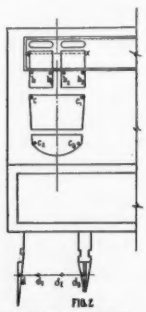


FIG. 2. PLAN OF STATION INDICATING POINTS AT WHICH HEAD MEASUREMENTS WERE MADE

The area of each gate opening in front of the turbines is approximately 540 sq. ft., an area which with one current meter would involve some 60 measurements and five hours to effect them with any pretense at precision. To economize time 14 current meters were used. This use of several current meters was considered feasible after some previous experiments had proved that the objection to using several instruments that of the calibration factor of one meter not being valid when several are used, was unfounded.

At a height of 6 ft. 6½ in. above the bottom of the sluices a plank floor was laid extending to the guide channels for the stop logs in one direction and to the trash racks in the other, the sluices being raised so that their bottom edges were on an exact level with the concrete beam in front. Immediately behind the gates and on a level with their bottom edges a horizontal plank deck was built. This deck together with the bottom edge of the gates and the concrete beam in front of the gates formed the upper boundary of the measurement of cross section. The sluice gate channels were filled in so as to render the side walls smooth and parallel. At the inner end of this run, x-x Fig. 2, the current meter measurements were made, guides being fixed to the walls of the turbine flume for the current meter frames.

The arrangement of these frames is shown in Fig. 1, meters being located at *a, b, c, d, e, f* and *g* at the center distances shown. They are all in the same horizontal plane and the whole frame is capable of vertical movement. Measurements were taken at ten different levels over a total height of 29 ft. 3 in., the lowest and highest levels being 4 in. above the bottom and 4 in. below the top. Two such frames were used in each cross section and each observer had two meters to look after.

Head Measurement

For this purpose making head measurements five stations were provided although the first two have no bearing upon the efficiency, being merely instrumental in arriving at head losses in the plant. These stations are shown at *b, c* and *d* in Fig. 2. At a point *a* in the head race, a fixed measuring rod was used readings being taken every five minutes. At point *b* in front of the ice screens four rods were set up at *b*, b_1, b_2 and b_3, readings being taken here every four minutes. At *c* in each corner of the turbine flume are located rods *c*, c_1, c_2 and c_3 also read at four minute intervals. At *d* are four movable rods *d*, d_1, d_2 and d_3 in addition to which readings were taken at four points just outside the adjacent discharge flume as a check. It was found that the water level at *d* was somewhat lower than that further out in the tail race due to the conformation of the draft tube discharge end in the form of a regainer. Point *e* gave measurements which correspond practically with the tail race level. During the test the level at *e* was consistently higher than at point *d* so that in reality measurements of the net head are somewhat unfavorable to the turbine builders. The gross head taken for daily operating results is *a* minus *d*.

Electrical Equipment

Electrical equipment consisted of a water resistance designed for 7500 v. It was placed outside the power house and connected by cables to the bus bars. Five-minute readings were taken on specially calibrated instruments and a constant output maintained by a load limiting device on the turbine governor.

Results of Tests

In the official tests of these turbines most elaborate arrangements were made to insure accuracy, no less than 25 men being employed at the various observation points. One and a half hours was the average time required to obtain a full set of readings. The observations tabulated were:

Time.
Water level observations at *a, b, c, d* and *e* (Fig. 2).
Net head *c-d*; gross head *a-e*.
Vane opening.
Vacuum.
Revolutions per minute.
Shaft horsepower.
Measured water volume.

Figure 3 shows the test results of turbine No. 1 plotted and as calculated to a net head of 40 ft. The maximum efficiency it will be observed is 90.1 with the turbine developing 11,360 hp., a high efficiency for this type of turbine, higher than the guarantee and considerably better than that of the model whose dimensions were in the ratio of 13 to 59. It might also be noted that the six turbines which are practically identical were made by two different firms. Curve No. 1 in Fig. 3 relates to a turbine of one make and curve No. 2 refers to a unit of the other make. Although the latter have a lower maximum efficiency they gave the best results at low loads. As a mat-

ter of fact, although the turbines of both concerns are practically identical each builder had a free hand in runner design, resulting in considerable difference in construction. The first three turbines have a comparatively small number of short straight buckets and the other three have both more and longer buckets. In both cases the buckets are of plate steel cast into cast steel hubs and shrouds. These turbines are typical of Scandinavian practice,

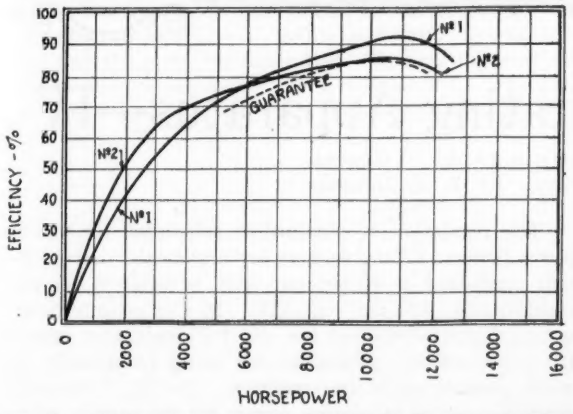


FIG. 3. PERFORMANCE CURVES OF TWO MAKES OF TURBINES

where for large powers on moderate falls the double wheel horizontal turbine is nearly always preferred to the vertical, even where the conditions would be pronounced by American designers to be entirely favorable to the latter. During the last few years, a large number of turbines of this class have been installed.

Diesel Engine Drives River Towboat

APPLICATION OF REVERSIBLE, SOLID-INJECTION ENGINES TO SPLIT STERN-PADDLE WHEEL

RELIABILITY rather than economy has, heretofore, been the chief consideration in the construction of middle western river steamers, as the possibility of the machinery stalling and a steamer going over a dam would be disastrous to the operation of the boat. Credit for designing and owning the first reversing-at-the-engine, stern-wheel towboat goes to T. L. Herbert & Sons of Nashville, Tenn. Records show a consumption of ½ lb. of fuel oil per hp.-hr. used by the Diesel engines and fuel and lubricating oil bill for a 10-hr. day of $9.50.

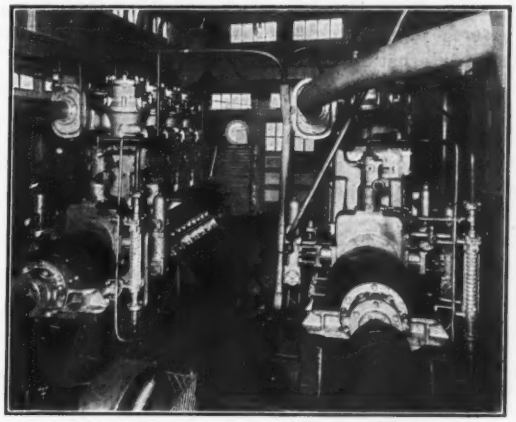
MECHANICAL DETAILS

Built by the Nashville Bridge Co., The Harvey, the new boat, has steel hull and main deck with wood superstructure. She is 113 ft. over all, 26 ft. beam, with mean draft of 3 ft. Speed, light, is 12½ mi. per hr. Fuel oil tanks to hold 120 days supply are located under the engine room.

Two Worthington Diesel engines, four-cylinder, two-cycle, solid injection, direct reversible marine type, of 120 hp. each at 375 r.p.m. drive line shafts which run aft to a point about 10 ft. forward of the stern. There a sprocket wheel on each shaft, with three teeth abreast, drives a triple-strand, 2-in. pitch roller chain which, in turn, drives a fore and aft outboard shaft at 74 to 78 r.p.m. Each shaft, by means of bevel gears operates half of the stern paddle wheel at 19 r.p.m. Each engine drives its own half of the paddle wheel independently so that the boat can be maneuvered effectively and, in case of emergency, the boat can be operated by one engine.

Shafting, cams and valve gear are concentrated in a housing that encloses the forward end of the crank shaft. One cam operates an air-starting valve which goes out of action when the engine begins firing. Eccentrics drive the pumps which deliver fuel to the spray valves on top of the cylinders; also a fuel transfer pump to deliver oil from the storage tanks to a strainer box on the top of the control housing. Other eccentrics drive pumps for bilge and circulating water, a lubricating oil pump and a two-stage air compressor.

In the cylinder head is a pre-combustion chamber which makes the rate of combustion in the cylinder inde-

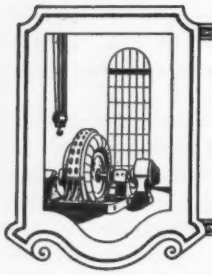


DIESEL ENGINES OF THE TOWBOAT HARVEY

pendent of the rate of injection of the fuel. Combustion in the cylinder is regulated by the piston which, through differences in pressure, controls the rate of flow of fuel and unused air through an ejection orifice in the bottom of the pre-combustion chamber. In front of the orifice, the center of the cylinder cover is dome shaped, flattening out at the edges which, with the flat top of the piston, causes the air to concentrate before the orifice. Space for the circulating water in the cover and around the cylinder can be easily inspected and cleaned which removes the danger of cracking from scale formation.

Further details cannot be given here but can be found in a book issued by the Worthington Pump and Machinery Corp'n. which can be had by writing to them.

TO KEEP brass from tarnishing: After thoroughly cleaning and removing the last traces of grease, by the use of potash and water, the cage or other brass work must be carefully rinsed with water and dried but in doing it, care must be taken not to handle any portion with the bare hand nor anything else that is greasy. The preservative varnish may be shellac, much diluted with alcohol, or it may be hard oil finish. In either case, the brass should be made pretty warm, and the varnish or shellac put on with a brush in as thin a coat as possible. The proportion of shellac to alcohol is about 2 oz. of the former to 9 oz. of the latter. Sometimes gamboge is used for a coloring matter, to make the varnish more yellow, and sometimes dragon's blood.



ELECTRICAL MACHINERY FOR LIGHT AND POWER

Operation of A. C. Generating Apparatus---IV

A Study of the Characteristics of A. C. Generators Under Various Conditions. By V. E. Johnson

IN THE PRECEDING articles of this series, we have covered in more or less detail the fundamental principles of alternating currents. We shall now take up the various conditions that exist in an alternating-current generator under various external influences.

If an alternator be run at constant speed, and with no load, and a number of different excitation voltages be applied to it, the voltage will vary with the excitation, and the result may be plotted as in Fig. 1. This curve is called a no-load saturation curve. The droop at the upper end is caused by the fact that the iron becomes filled with magnetism to such an extent that increasingly large increments of exciting current are necessary to produce equal increments of terminal voltage. The excitation is controlled by the exciter field rheostat, by the main field rheostat, or by both.

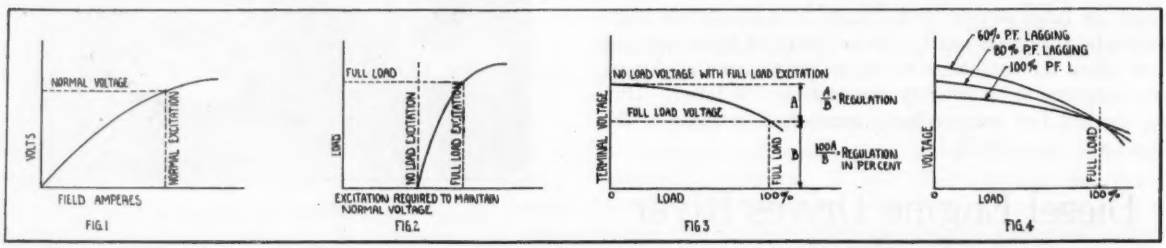


FIG. 1. NO LOAD SATURATION CURVE OF AN A. C. GENERATOR. FIG. 2. LOAD-FIELD CURVE. FIG. 3. REGULATION CURVE OF AN ALTERNATOR. FIG. 4. A SET OF REGULATION CURVES OF A MACHINE UNDER VARIOUS POWER FACTORS

If the voltage be kept constant, and a load at a fixed power factor be applied gradually, the excitation will need to be increased as load is applied. Figure 2 shows a curve plotted on this basis. If on the other hand, a generator is excited to produce normal voltage at full load and the load removed gradually, keeping the excitation constant, the voltage will rise with the decrease in load, and a curve such as is shown in Fig. 3 will be obtained. This is called a "regulation" curve, and shows the rise in voltage under constant speed and excitation from full load to no load. In this connection then we get the term "regulation" which is roughly defined as the increase in voltage as above—and notwithstanding, is expressed thus: Percent regulation

$$= \frac{(\text{No load voltage} - \text{full load voltage})\ 100}{\text{full load voltage}}$$

under full load normal voltage excitation.

The regulation so obtained is calculated for various power factors. Thus, we may say a generator has 13 per cent regulation at 80 per cent P.F. or again 8 per cent regulation at 100 per cent P.F. In the manufacturers' testing departments the 0 per cent P.F. regulation curve is the one commonly obtained—this being incidentally the worst possible operating condition. In Fig. 4 is shown roughly a set of regulation curves for the same machine under varying power factors. These indicate, if we look at them in a different, and perhaps simpler light, that a given load at a low power factor lagging causes a greater voltage drop than the same load at unity power factor. Conversely, a leading power factor load holds the voltage up, so that its effect is exactly opposite that of a lagging power factor.

Broadly speaking this is due to the same conditions that cause the regulator of a d.c. machine to be affected by the movement of the brushes forward or backward, as we saw in the discussion of this phenomenon in a previous article. Thus, moving the generator brushes forward, makes the armature magnetism oppose the main fields to a greater or less degree, and so reduces the terminal voltage, on the other hand setting the brushes back of neutral causes the armature magnetism to aid the field magnetism and, as a consequence, the voltage is raised.

Referring now to an alternator, if the current taken from it lags behind the generated voltage, the magnetism set up in the stator core by the current opposes the main field flux and so weakens it. On the other hand, if the current taken from the stator leads the generator voltage, the armature magnetism will boost or assist the main field, and the voltage will rise.

This analogy becomes clearer if one considers that in a d.c. machine, with the brushes forward the current really,

in a sense, lags behind the voltage, in that a given commutator bar comes under a brush after a delay equal to the interval elapsing between the instant it passes neutral, and the time it connects with the brush.

Inasmuch as the effect of power factor on voltage regulation is a factor that must be constantly reckoned with, a more thorough discussion is justified.

We have already stated that the power factor of a given load is determined by its nature, giving as examples a resistance, a magnetic coil, and a condenser. Let us consider first the plain resistance load. In Fig. 5 is shown a generator supplying current to a resistance R. The current I flowing through it is in phase with the voltage E across its terminals, while the resistance drop is exactly in

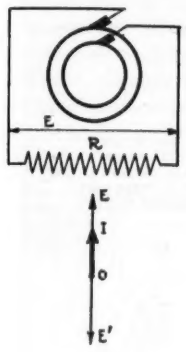


FIG. 5

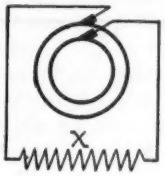


FIG. 6

IN THIS CASE OE = OE', AS ALL OF THE VOLTAGE IS APPLIED TO THE TERMINALS OF THE COIL X

FIG. 7

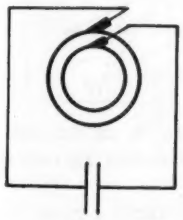


FIG. 8

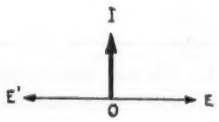


FIG. 9

FIG. 5. GENERATOR SUPPLYING A RESISTANCE LOAD WITH CORRESPONDING VECTOR

FIG. 6. CIRCUIT CONTAINING A COIL HAVING INDUCTANCE

FIG. 7. VECTOR RELATIONS OF VOLTAGE AND CURRENT IN INDUCTIVE CIRCUIT

FIG. 8. CIRCUIT CONTAINING CAPACITY ONLY

FIG. 9. VECTOR RELATIONS OF CURRENT AND VOLTAGE OF CIRCUIT IN FIG. 8

opposition to it. The additional voltage which is required to overcome this drop, is therefore in phase with the current. Thus, in Fig. 5, OE is the vector representing the generated voltage, OI is the current which flows, OE' is the voltage drop. OE', in this case, is exactly equal to OE and the resultant is zero; that is to say, the entire load consists of this resistance R and the entire voltage is used in passing current through it. A circuit of this kind obeys Ohm's law for direct current—that is

$$I = \frac{E}{R}. \quad R = \frac{E}{I}. \quad E = IR.$$

In Fig. 6 is a circuit containing a magnet coil having no resistance. The flow of current through it is limited by the "back voltage" set up in it by the induced magnetism. This is commonly spoken of as the inductance and is usually designated by the letter X. The current through the coil is not in phase with the voltage but is 90 deg. out of phase. The voltage drop IX is 90 deg. behind the current, and the voltage necessary to overcome this drop is 90 deg. ahead of the current. The proof for this will not be

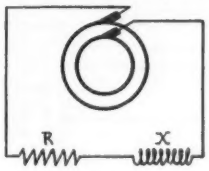


FIG. 10

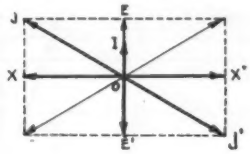


FIG. 11

OI = CURRENT
OE' = RESISTANCE DROP
OX' = INDUCTANCE DROP
OJ' = RESULTANT, OR IMPEDANCE DROP

OE = VOLTAGE TO OVERCOME OE
OX = VOLTAGE TO OVERCOME OX
OJ = RESULTANT OR TERMINAL VOLTAGE, IT EQUALS OJ BUT IS 180° OUT OF PHASE WITH IT.

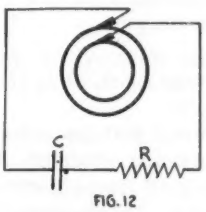


FIG. 12

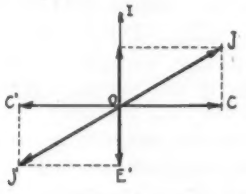


FIG. 13

OI = CURRENT
OC' = CAPACITY DROP
OE' = RESISTANCE DROP
OJ' = RESULTANT OR IMPEDANCE DROP.

OC = VOLTAGE OVERCOMING OC'
OE = VOLTAGE OVERCOMING OE'
OJ = THEIR RESULTANT OR THE TERMINAL VOLTAGE.

FIGS. 10-13. CIRCUITS WITH COMBINATIONS OF INDUCTANCE, RESISTANCE AND CAPACITY AND THEIR CORRESPONDING VECTORS

given but the condition is shown in Fig. 7 where OI is the current flowing in the coil, OE' the inductive drop, and OE the voltage necessary to overcome it.

In an analogous manner in a circuit such as in Fig. 8 which contains capacity only, the vector relations may be shown to be as indicated in Fig. 9 where OE' is the capacity drop, and OE the terminal voltage.

A tabulation makes this a little clearer.

Nature of Circuit	Phase relation of drop to current	Phase relation of voltage to overcome drop to current	Phase relation of current to terminal voltage
Resistance	180° out of phase	In phase	In phase
Inductive	drop 90° behind current	E 90° ahead of I	I 90° behind E
Capacity	drop 90° ahead of I	E 90° behind I	I 90° ahead of E

If a circuit contains both inductance and resistance as in Fig. 10, the induction and resistance drops are overcome by components of the voltage which may be represented vectionally as in Fig. 11. Here the total opposition to the flow of current is the "impedance."

It can be seen that this is the hypothenuse of a right-angled triangle whose base and altitude are the resistance and inductance components respectively.

If a circuit contains both resistance and capacity as in Fig. 12, then the resistance and capacity drops are overcome by components of the voltage which may be represented vectorially by Fig. 13. This resembles Fig. 11 except that the current is ahead of the voltage.

If a circuit contains resistance, inductance and capacity, the vector relations would be those in Fig. 14. The resultant would be found by finding the algebraic sum of the inductance and capacity components and drawing the hypothenuse, using this sum as one side of a right angled triangle of which the resistance component formed the other. It can be seen here that the impedance drop (the hypothenuse) would be in phase with the current if the

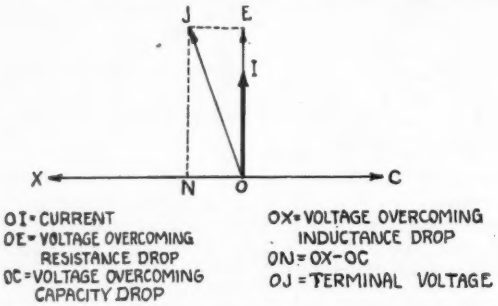


FIG. 14. VECTOR RELATIONS OF A CIRCUIT WITH RESISTANCE CAPACITY AND INDUCTANCE

capacity and inductive components were equal, as in that case they would exactly cancel each other.

In the foregoing it has been assumed that the inductance, resistance and capacity were physically separated. As a matter of fact, most circuits contain all three; however, in generator and transformer windings, etc., the capacity component is so small as to be negligible.

A generator winding contains both resistance and reactance. (Reactance is a term used to cover both inductance and capacity.) Therefore, the drop of voltage occasioned by the flow of load current through its windings, would be the resultant of ohmic (resistance) and reactive drops, and voltage would have to be generated to overcome these in order to maintain a constant terminal voltage. If such additional voltage were not generated, the terminal pressure would drop.

Assuming that the capacity of the generator windings be negligible and that the external circuit contains more inductance than capacity so that the load current will lag behind the terminal voltage, the conditions can be represented by Fig. 15. The vector OI represents the current. OX is the "reactive internal drop" component of the generated voltage. This is 90 deg. ahead of the current. XR is the internal "resistance drop" component of the generated voltage, and is in phase with the current flowing. OR then becomes the voltage component which overcomes the impedance drop. If the external load is such as to cause the current to be behind the terminal voltage by the angle ϕ, then the line RE represents this, as the angle I'RE is the angle ϕ. The total generated voltage must be EO, the resultant of the necessary external voltage and the internal armature drop RO, added vectorially in their proper phase relations. The triangle ORX is usually spoken of as an "impedance triangle."

It will be seen that for a given terminal voltage, and a given current, the line RE is of constant length, and the impedance triangle of constant dimensions; however, as the angle ϕ changes with varying power factor conditions, the line EO varies. Thus, in Fig. 16, the impedance triangle rotates about the point R and assumes positions such that the angle XRX" (which equals ERI' in Fig. 15) is the angle of lag. It will be seen that the voltage drop, that is the difference between the generated voltage EO and the terminal pressure ER, varies widely with the power factor. It will be seen, too, that for leading power factors, the impedance triangle comes into a position where the terminal voltage is greater than the generated pressure—a condition which seems impossible but which actually is of frequent occurrence. Thus a machine having a terminal voltage of 2300 v. at no load (this is also the generated voltage under no load conditions) may, upon connection to a circuit having capacity, rise to 3000 v. or more.

It is evident, then, that the regulation of a generator must be expressed with reference to a given power factor condition; otherwise it has no meaning. It is also evi-

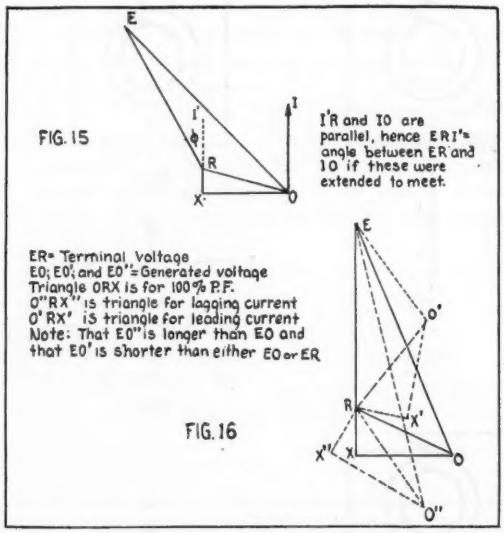


FIG. 15. VECTOR RELATIONS IN AN A. C. GENERATOR
FIG. 16. SHOWING ROTATION OF IMPEDANCE TRIANGLE

dent that it requires more excitation to carry a given load at a lagging power factor than under unity or leading conditions. This increase of excitation increases field heating, and of course so reduces the available capacity of the generator.

Testing for Rotation of Watt-hour Meters

CORRECT ROTATION OF METER ELEMENT IS NOT ALWAYS AN INDICATION OF PROPER CONNECTION. BY F. C. DE WEESE

IN CONNECTING POLYPHASE watt-hour meters in circuit great care should be exercised in order to make certain that the potential and grid circuits are connected across the proper phases and also that they are connected so as to produce fields in the right direction. This requires special attention in order that current rotation may result. Even though current rotation is secured, the connection may not be properly made. This condition results in an incorrect registration of the power.

It is quite often the case that in connecting up polyphase metering installations requiring the use of instrument transformers, men are called in who are not techni-

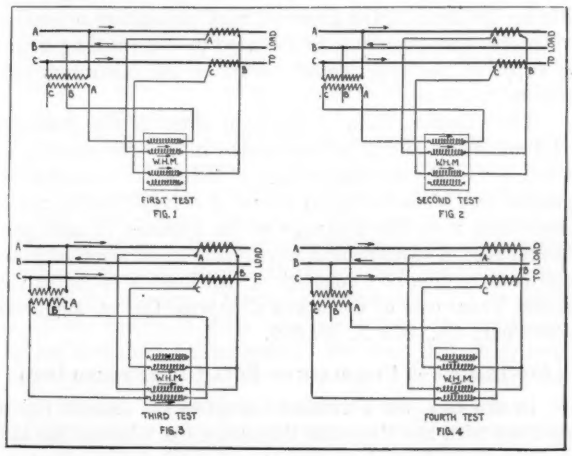
cally familiar enough with this class of work to be able to make the necessary tests for determining the correct connections.

It is for the benefit of those who are not familiar with this work that this article is presented. The diagrams shown, herewith will serve to illustrate the method used. This method is applicable for use regardless of whether the power factor of the load is above 50 per cent or not.

To apply this method, first, tag the instrument leads so that they will be easily identified, and it is well to tag the secondary leads of the potential transformers connected across phases A and B, the same as secondary leads of the current transformer that are to be connected in phase A. This will assure that you will not cross the phases.

First Test: Connect the watt-hour meter to the system as shown in Fig. 1, connecting the potential coil of the upper element between A and B and the potential coil of the lower element being left open.

Next: Change the connection of the potential coil of the upper element from AB to AC, as shown in Fig. 2. If the power factor should be just 100 per cent, the speed of



FIGS. 1-4. DIAGRAMS ILLUSTRATING VARIOUS STEPS IN TESTING WATT-HOUR METER CONNECTIONS

the rotating element will be the same with both connections; if the power factor of the load is above 50 per cent but less than 100 per cent, the speed of the rotating element will be different from that of the first connection; if the power factor of the load is below 50 per cent the meter will rotate in the opposite direction.

The same method should be followed with the lower element, connecting first as shown in Fig. 3 and next as shown in Fig. 4. These connections are relatively the same as those made with the upper element. If the power factor of the load is exactly 100 per cent, which is rarely ever the case, the speed of the rotating element will be the same with both connections. If the power factor of the load is less than 50 per cent the direction of rotation will be in an opposite direction from the first, if the power factor of the load is less than 100 per cent but more than 50 per cent the meter will rotate in the same direction as with the first connection, on the lower element.

If it is found the power factor of the load is above 50 per cent, connect the two elements of the watt-hour meter so that either element rotates the meter in the forward direction when operating separately, being very careful to see that the potential coils of the upper element are connected between A and B and the potential coil of the lower element between C and B. The current coil of the upper element is to be connected in phase A and the current coil of the lower element connected in phase C. If the power factor of the load is found to be below 50 per cent connect the potential coil of the slower element (when the potential coils of the two elements are connected between AB and CB respectively) so that the rotating element revolves

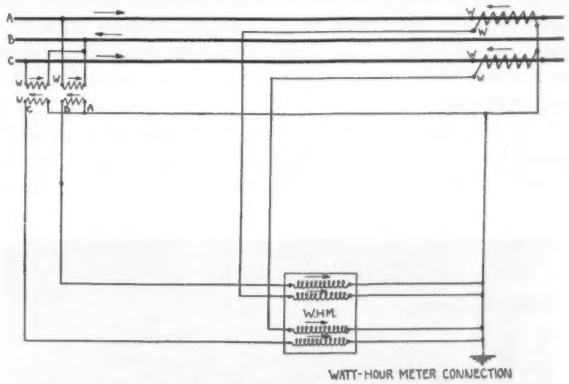


FIG. 5. ANOTHER METHOD USED IN MAKING POLYPHASE METER INSTALLATIONS

backwards when operating separately. The faster element then must be connected so as to rotate the rotating element in the forward direction.

Another method that the writer has found to be satisfactory, when sending men into the field to make polyphase meter installations, is shown in Fig. 5. The instructions accompanying this diagram are as follows:

Connect the white primary leads of the potential transformers to the two outside primary phases; connect the black primary leads together and to the middle phase; connect white secondary leads to the incoming, or line side of the meter; connect black secondary leads together and to the load side of the meter. Connect the white primary terminal of the current transformers to the line side of the line; connect the black primary terminals of the current transformers to the load side of the line. Connect white secondary leads of the current transformers to the line side of the meter and the black leads of the current transformers together and to the load side of the meter. After these connections are all made, connect all potential and current leads, on the load side of the meter together and to ground. Be sure to see that the potential and current transformers that are connected to the same relative phases, are connected to the same relative elements in the meter. After the connections are all made, check the connections again, to be certain you have not crossed the phases.

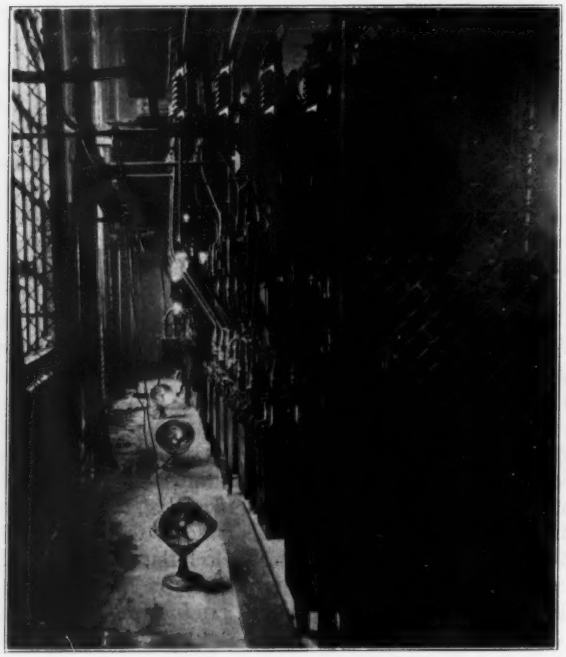
These simple instructions are quite easily carried out. The average man takes pride in being able to do this kind of work properly and it is rarely ever the case that you will find an error resulting in the connections.

In making polyphase watt-hour meter connections, where it is necessary to use instrument transformers, the potential transformers should be connected on the line side of the meter, or in other words, ahead of the current transformers and not on the load side. If they are connected on the load side of the current transformers, the losses in the potential transformers will flow through the current transformers and will thereby be registered on the meter.

Radiant Heaters Keep Ice Off Bus Bars

AN INTERESTING INCIDENT illustrating the resourcefulness of the operating engineer was recently brought to light while visiting a small Middle Western power plant. The plant was an old one in which a number of obsolete Corliss engines had been replaced recently by a new turbo-generator. Little attention, however, had been given to improving the buildings in which the equipment was housed. The plant had been built in sections to accommodate its growth and one of the sections had a concrete roof.

In cold weather this roof had a tendency to sweat, a condition which caused considerable annoyance, particularly above the switchboard where the dripping water



RADIANT HEATERS PREVENT FORMATION OF ICE ON REAR EQUIPMENT

played havoc with the insulation. To overcome trouble at this point, a corrugated sheet iron covering had been installed about 10 ft. above the top of the switchboard so as to catch the drippings. Under ordinary conditions this arrangement solved the problem insofar as the switching apparatus was concerned.

One night during a recent cold spell, however, when the outside temperature went down to some 10 deg. below zero, even the protective sheet iron covering commenced to sweat, and to further augment the trouble, the vapor, with which the room was filled, condensed on the busses and insulators back of the board. The rear of the board faced an outside wall and in a short time, the insulators, bus bars and other rear equipment were covered with a coating of ice.

By the time the operator first became aware of this condition, the insulation was in danger of failing at a number of points. The situation was serious. He had to do something and he had to do it quick!

He was equal to the emergency, however, and sent a hurry-up call to the electric appliance store a few blocks away for a number of household type radiant heaters. These were rushed to the plant and connected up behind the switchboard as shown in the accompanying illustration. The result was, that in a few minutes all rear equipment was clear of ice and the heat effectively stopped all further condensation.

Contract for Purchase of Fuel Oil

To Avoid Litigation a Requirement Clause Should Not Accompany a Maximum and Minimum Clause. By Leslie Childs

IN THE making of industrial contracts for supplies, where the express purpose is to provide material necessary for the operation of a plant over a stated period, the insertion of clauses requiring the delivery of a maximum and minimum quantity has been a frequent cause of dispute and litigation. This is true because a sharp rise or fall in the market price of the commodity contracted for, during the term of the contract, may precipitate a conflict of interests that can only be adjusted by determining which is superior, the requirement clause or the maximum and minimum clause.

The question, then, of the legal effect of the insertion of a maximum and minimum clause in a requirement contract, is one of great importance to industrial executives in general and while the point is one of some difficulty, much depending upon the language of the contract in each particular case, a valuable and worthwhile illustration of judicial construction of a contract of this kind is found in the recent Texas case of Corsicana Compress Co. vs. Magnolia Petroleum Co., 253 S. W. 559.

Contract For Purchase of Fuel Oil Entered Into

In this case, the Corsicana Compress Co. entered into a contract with the Magnolia Petroleum Co. whereby the latter agreed to furnish it with a quantity of fuel oil at an agreed price of one dollar per barrel. This contract was reduced to writing, and among other things provided.

"Said seller hereby agrees to sell and deliver to said buyer, said buyer agrees to purchase and receive from the seller, between June 17th, 1919, and June 17th, 1920, the fuel oil necessary to supply fuel and operate a compress during the term of this contract and not thereafter, not to exceed a maximum of 4000 barrels, which maximum the seller agrees to furnish and the buyer to take if required for said purposes, and not less than a minimum of 3000 barrels, which minimum the buyer contracts and guarantees it will take and, the seller agrees it will supply, for such fuel purposes. * * *"

Under this contract the Magnolia Petroleum Co. had made delivery of 943.65 bbl. of oil up to June 4, 1920, and in the meantime the price of oil had advanced from one dollar a barrel to three dollars a barrel. On the last named date, when the contract was about to expire, the Corsicana Compress Co. made a written demand for future deliveries of oil. This demand was refused by the Magnolia Petroleum Co. on the grounds that the contract only obliged it to deliver the oil necessary for the operation of the other's plant during the life of the contract.

In reply to this the Corsicana Compress Co. contended that it was entitled to delivery of the minimum quantity

named in the contract, namely 3000 bbl. The contention being that the maximum and minimum clause in the contract was controlling as against the clause stipulating for the delivery of oil necessary for the operation of its plant during the period named.

Following a dispute the Corsicana Compress Co. filed suit for the purpose of obtaining damages at the rate of two dollars a barrel for the oil not furnished under the minimum clause of the contract. Upon the trial of the cause in the lower court the Magnolia Petroleum Co. was awarded a judgment. From this judgment the Corsicana Compress Co. prosecuted an appeal to the higher court.

Here, in the face of the facts and the contentions of the parties, the question squarely in issue was whether the requirement clause, or the maximum and minimum clause, of the contract was controlling. In passing upon this point the higher court reasoned in part, as follows:

What the Court Decided

"If it was the intention of the parties to contract for such an amount of oil only as was needed to supply fuel for operating the compress for one year, why name any number of barrels, at all, either a maximum or a minimum? Frequently contracts to supply commodities are made between parties for the amount of their necessities for a stated time, which are limited to a maximum amount to be furnished but, if a contract contemplates the supply to be the full amount that may be needed by the purchaser, why should there be a minimum stated? If the parties contracted with that in view, why the guaranty clause obligating the purchaser to take any pay for a minimum amount? If it was not the intention of the parties to fix a minimum quantity to be bought by appellant (Corsicana Compress Co.) and delivered by appellee (Magnolia Petroleum Co.) at 3000 bbl., it was useless to write into the contract the language, 'and not less than a minimum of 3000 barrels.' Why not, if a maximum was desired to be fixed, have named the maximum and then added: or such amount of such oil as purchaser may require for operation of said compress for said time? * * *"

After further reasoning in the same tenor as set out above the court proceeded to sum up its conclusions, relative to the meaning of the parties as expressed in the contract. In this connection it was, among other things, said:

"It is clear, we think, looking to all the language used by the parties, that the intention was to bind the appellee to sell to appellant, and appellant to buy from appellee, all the fuel oil, not exceeding 4000 bbl., used by appellant in operating its compress between the dates specified, and, without reference to whether it used it during that time or not, to bind appellant to buy from appellee and appellee to sell and deliver to appellant for fuel purposes as much as 3000 bbl. of fuel oil. * * *"

Conclusion

In conclusion the higher court reversed the judgment rendered in favor of the Magnolia Petroleum Co. in the court below, and ordered judgment rendered in favor of the other for the sum of $4,112.70, that being the assessed damages at the rate of two dollars per barrel for the oil not delivered under the minimum clause of the contract. Holding, as outlined in the opinion, that the Corsicana Compress Co., under the contract, was entitled to the delivery of the minimum amount named, regardless of the requirement clause and whether same was used during the term of the contract or not.

This Texas decision is one of value on the point decided. In the light of its facts and holding it is obvious that great care should be exercised in drawing contracts of this kind if all danger from after dispute is to be guarded against. Certainly with this case in mind, a maximum and minimum clause should not be used in connection with a requirement clause, unless its meaning is made perfectly plain by the context of the agreement, for as we have seen, its use may easily become a source of after dispute and possible litigation, which should be guarded against in the beginning.

Anheuser-Busch Coal Handling Costs

By Henry Vorhof*

IN JULY, 1908, when the boilers in the Anheuser-Busch plant power plant were equipped with automatic stokers, a Peck carrier for delivering the coal to the bunkers over the boilers was installed. Bottom dump cars discharge the coal into a hopper below the railroad siding. It passes through a coal crusher, and onto a short inclined conveyor which delivers it to the carrier.

This elevator consists of 274 steel buckets mounted into an endless chain 548 ft. long, which travel horizontally in the basement underneath the front of the boilers,

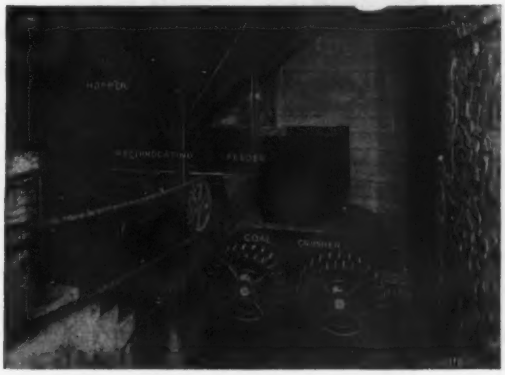


FIG. 1. THE COAL CRUSHER DISCHARGES TO AN INCLINED CONVEYOR LEADING TO CARRIER

vertically at one end of the boiler room, horizontally over the bunkers, and down the other end of the boiler room. The coal, which is placed in the buckets by the inclined conveyor in the basement, is elevated 50 ft., and dumped automatically into the proper bunker by means of a tripper set by the man who has charge of the carrier's operation. There are 14 bunkers into which the coal is distributed. From the bunkers the coal flows through chutes by gravity to the automatic stokers. A 20-hp. motor provides the power for driving the equipment.

In 15 yr. the carrier has been out of use only once—for two or three days—when we changed a gear wheel. Aside from this instance the conveyor has never missed a day and we use it 365 days in a year. More than half of the original buckets are still in use.

Handles Both Coal and Ashes

All the machinery in this plant is given good care, and the coal elevator is no exception. The rollers are oiled reg-

* Chief Engineer, Anheuser-Busch, Inc., St. Louis Mo.

ularly once a week. This is an hour and a half job for four men. About every 2 yr. the rollers are inspected and new bushings put in where required.

Handling five 50-T. cars of coal to the bunkers per day, is the principal work of the carrier. We also use it as an ash conveyor. Men scrape the cinders from the ash pits onto the conveyor in the basement, and they are carried to a chute into which they are dumped automatically. They discharge into a railroad car. We take out approximately one carload of cinders per day. Drip coal, which falls through the chain grates, is taken back to the bunkers by the carrier.

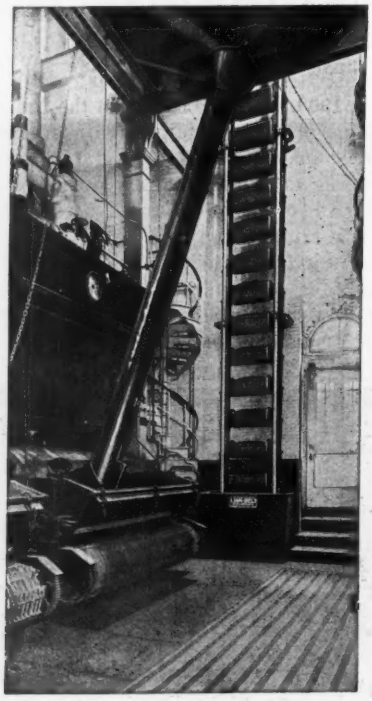


FIG. 2. COAL ELEVATOR IS OPEN TO VIEW FROM FIRING AISLE

As shown on the cost sheet attached, the cost of coal elevating is $0.035 per ton. This includes depreciation on the basis of 25 years' life, average interest, repairs, power, and labor. An annual allowance of $1200 for all repairs and maintenance is made, which covers parts required, labor of oiling, and overhauling expense. Of this total fixed expense per day two-thirds is charged to coal elevating.

COST OF OPERATING COAL AND ASH CARRIER

Depreciation, $10,500.00 ÷ 25 yr. life	$ 420.00
*Average interest @ 6% $= \frac{26}{25} \times \frac{\$10{,}500.00 \times .06}{2}$	327.60
Maintenance and repairs estimated	1200.00
Total annual fixed expense	$1947.60
Total fixed expense per day, $1,947.60 ÷ 365 days	5.33
Fixed expense per day chargeable to elevating coal to bunkers, ⅔ × $5.33	3.55
Power, 58.5 kw.-hr. @ $0.03 per kw.-hr.	1.76
Labor, 5 hr. @ $0.70 per hr	3.50
Total cost per day, elevating coal	$ 8.81
Tons coal handled per day	250
Cost per ton $8.81 ÷ 250 T	0.035

*Allowing for interest earned by depreciation reserve.

Money Saved by Reducing Slip

BY W. F. SCHAPHORST

TO SHOW how important it is to reduce belt slip to the minimum, I have prepared the accompanying useful and convenient chart. Much more money can be saved in this way than is generally believed.

Let us suppose that your main drive belt, transmitting 100 hp., slipped 4 per cent. You decided that the pulleys were too small and installed larger pulleys. Thereafter you discovered that the slip was only 2 per cent. The saving of difference in slip is therefore 2 per cent.

THIS CHART GIVES THE MONEY SAVED BY REDUCING BELT SLIP

To use the chart connect the horsepower transmitted, column A, with the difference in slip column C and the intersection with column B gives the annual saving in dollars. Thus the dotted line drawn across this chart solves the preceding problem where 100 hp. is transmitted and where the difference in belt slip is 2 per cent. The annual saving is nearly $400 as the intersection with column B shows.

The chart is based upon continuous operation and upon a power cost of 3 cents per kw.-hr., which is surely a conservative figure. It is much below the average cost of power in the United States.

In case the cost of power is more or less, divide the figure obtained in column B by 3 and multiply by the actual cost in cents and the result will be the annual saving in dollars. Thus if the cost of power is 5 cents per kw.-hr., we would have, applying it to the foregoing problem, $400 ÷ 3 = $133.33; then $133.33 × 5 = $666.67, the annual saving.

Effect of Compound Compression of Ammonia

Cost of Extra Equipment, Will in Most Cases, Offset the Thermodynamic Gains Which Would Result From Compound Compression. By John E. Starr

COMPOUND compression will generally show a distinct thermodynamic gain but it will not in all cases show a final commercial gain. The reason for the advantage in compound compression lies almost entirely in two things: First, the reduction of the inevitable amount of what might be called "heat slippage" from the high or hot side of the cylinder to the cooler incoming gas; second, the ability to take out heat and therefore reduce power required before the compression of the gas is fully complete. Incidentally, there also exists the small advantage of taking some of the heat out of the liquid at a higher temperature than that of the evaporator and so giving a small gain from the heat handling standpoint. In any compression of gas, the pressure side of the piston and the walls of the cylinder are hotter than the average temperature of the gas entering the cylinder.

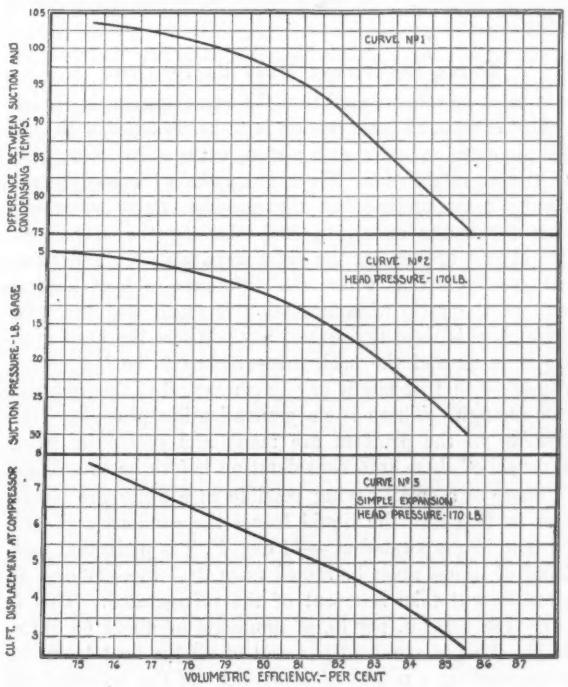
As heat always flows from a warm body to a cooler one, it follows that a certain amount of heat will always flow back from the hot discharge gas to the cooler incoming gas so requiring work that has once been performed to be done over again by increasing the volume of the gas in the cylinder and requiring a larger displacement per pound of gas. The return flow of heat is proportional to the difference in temperature between the warm side and cool side of the cylinder. Hence the volumetric efficiency of any compression cylinder is affected by this flow of heat.

When a gas is compressed it is always superheated far above its saturation or condensing temperature. The relation of heat flow has been pretty well established by comparing the inlet temperature to the condensing temperature; this averages in all well-constructed machines about as shown in Curve No. 1. The curved line represents the rate of volumetric efficiency at various differences of temperatures between condensing and suction temperatures. It will be seen that as the difference in temperature becomes greater the volumetric efficiency becomes less; as the difference in temperature becomes greater the volume of gas per pound of working fluid becomes greater, hence the horsepower per ton becomes greater because the tonnage depends on the weight of gas handled. This curve represents a case where the condensing temperature is due to that of ammonia at 170-lb. gage or 91.4 deg. F. The figures at the left designate the difference in the temperature between the boiling points of ammonia at different pressures and 91.4 deg. F. The figures at the bottom represent the percent of volumetric efficiency or the relation of actual cubic feet handled per ton to the volume of gas at evaporator temperature and pressure.

In Curve No. 2 the figures at the left indicate the pounds gage of back pressure and the figures at the bottom represent the volumetric efficiency when the head pressure is 170-lb. gage. In Curve No. 3 the figures at the left indicate the number of cubic feet displacement necessary in the simple compressor at each volumetric efficiency shown by the figures at the bottom.

It is apparent from these charts that the volume of gas to be handled by the compressor per ton per minute is in proportion to the difference of the suction and discharge temperature and that the tonnage will decrease for any given displacement as the difference in temperature or pressure becomes greater. Further that the horsepower per ton will increase as the difference in temperature or pressure becomes greater, or in other words, the tonnage on any given head pressure at the same compressor displacement will increase as the back pressure increases and the horsepower per ton will decrease.

If we were running at, say, 3-lb. gage back pressure and 180-lb. ammonia head pressure we would take in heat at



RELATION OF VOLUMETRIC EFFICIENCY TO TEMPERATURE DIFFERENCES, SUCTION PRESSURE AND COMPRESSOR DISPLACEMENT

about —21 deg. F. and discharge it finally at 94.7 deg. F., or a total heat head of 115.7 deg. Now, if we compressed first up to, say 75-lb. gage, we should still take in heat at —21 deg. F. but we should discharge it at 50 deg. F. or 71 deg. difference. If now we compressed in the second stage, the gas might enter the high-pressure cylinder at 50 deg. F. and leave it at a high temperature but condense at 94.7 or only 44.7 deg. difference, so instead of heat slipping back due to a heat head of 115.7 in the case of simple compression, we should nowhere have it slipping back at a rate due to a heat head over 70 deg. F. This shows that the condition in compound compression would be only about half as bad as in the simple compression case.

As a matter of fact, our temperature at the discharge of the low-pressure cylinder would be considerably over a temperature due to a condensing pressure of 75-lb. gage or 50 deg. F. for in compressing we must add heat to the gas—not only more heat than would bring it to the temperature at which it condenses but we must superheat it,

possibly to 120 or 130 deg. F. Here we can take out heat by the use of an intercooler, so that the gas will enter the high pressure cylinder not at the heat of its superheat but at a heat somewhere near the temperature of the cooling water or near 70 to 80 deg. F. In any event our total heat head in compound compression will not at any stage be as great as in simple compression.

In simple compression the heat that would have to be given the gas at these pressures would finally heat it to perhaps 300 or 350 deg. F. while in compound compression its final heat would not be nearly as high with the result that the incoming gas would not be "swelled" so much by heat and it would occupy less room per pound and require less work to be done on it per unit of refrigeration which is dependent on the pounds of refrigerating fluid handled.

Extra Equipment Must Be Provided

It must be remembered that the extra apparatus needed to effect compound compression is to be reckoned with. It costs an extra cylinder and piston, extra valve rods, gear and also an intercooler. We might make a thermodynamic gain by compounding but the question must be asked: "How far is the saving in fuel offset by the extra cost, interest and upkeep on the extra apparatus?" The practical answer is that where the difference in heat head is small or the ratio of compression is small and the total annual load is light it does not pay. Where the head pressure is large and the back pressure has to be low, say a ratio of 10 to 1, it might pay to compound if the load was large enough. There is no generalization possible. The variables in the problem are many and one must bring nearly all of them into consideration before he can judge.

There is a small saving possible in cooling the liquid. If as in this case the liquid leaves the condenser at 94.7 and is to be evaporated at —21 deg. F. it is plain that each pound of liquid must be cooled from 94.7 to —21 deg. F. before it will take heat out of the refrigerator. This is nearly 128.8 B.t.u. per lb. of ammonia or about 66 B.t.u. per T. This is about 23 per cent of all the heat taken up by evaporating a pound of ammonia. If the intermediate pressure be 75 lb. gage, it is quite possible to provide means for exposing the ammonia on the way to the evaporator to a pressure of 75 lb. gage where part of it will boil off at 50 deg. F. The balance may go to the expansion valve at 50 deg. F. instead of 94.7 deg. F. or about half of the work of cooling the liquid can be done at a back pressure of 75 lb. gage instead of a back pressure of 3 lb. gage. In this way we can do a small part of our total cooling at a much reduced cost but again, it costs money to supply the apparatus for cooling of the liquid partially and again comes the question—Does it pay?

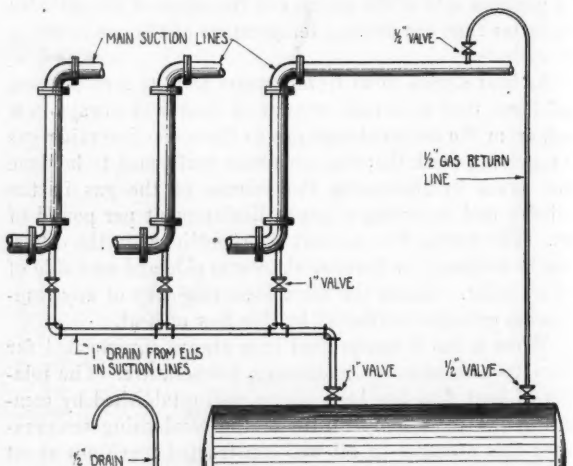
Cement of leather belting: Take of common glue and American isinglass equal parts; place them in a boiler and add water sufficient just to cover the whole. Let it soak 10 hr., then bring the whole to a boiling heat and add pure tannin, until the whole becomes ropy or appears like the white of eggs. Apply it warm. Buff the grain off the leather, where it is to be cemented; rub the joint surfaces solidly together, let it dry a few hours and it is ready for practical use; and if properly put together, it will not need riveting, as the cement is nearly of the same nature as the leather itself.

Simple Ammonia Purifier Proves Effective

By A. G. Solomon

IT IS not an uncommon occurrence to find the condition where oil and moisture in the ammonia system give considerable trouble because the methods provided for their removal are slow and ineffective. In one plant this condition was remedied by making use of an old tank which was connected to the lower ells of risers in the main suction lines.

Conditions had reached the stage in this plant where the amount of ammonia being used was increasing due to the decomposing effect of the moisture and the expansion valves were being blocked with oil. To provide for the removal of these impurities, oil traps were put on the discharge lines from the ammonia compressors, the drain



EACH SUCTION MAIN WAS CONNECTED DIRECTLY TO THE NEW RECEIVER

from each of these traps being connected into an ammonia purifier. As the purifier was surrounded by hot water most of the moisture was sent back into the system in the form of steam or vapor.

At one place in this system there were three suction lines running parallel for some distance; they then extended up for about 10 ft. to a higher level, at which they continued to the machines. For some reason each of the three ells at the lower level had been drilled and tapped and 1 in. nipples and valves put on. Pipe covering of the hairfelt and tar kind had been wrapped around these valves so they were completely hidden. When the covering was removed it was found that the valves were blocked with scale. The suction lines were pumped out and the valves cleaned, repaired and packed. New nipples were also put in because the old ones were badly rusted.

These 1-in. valves were a good suggestion for the removal of oil and moisture, for they were at a low point in the suction lines and also at a point where the direction of the flow of the vapor was changed from horizontal to vertical. This change would cause a check on the movement of any heavy moisture traveling along the bottom of the pipe. An old liquid receiver about 18 in. in diameter and

6 ft. long was cleaned and tested and the several 2-in. openings plugged. Then one 1-in. and two ½-in. holes were drilled and tapped in the proper places. This receiver was then placed in a room where the average temperature was about 75 or 80 deg. F. One end of the receiver was raised 2 in. higher than the other. A ½-in. drain valve was placed at the bottom of the lower end of the receiver. On top and at the center was the 1-in. opening for the oil and moisture to flow into the receiver and at the top of the high end was a ½-in. opening for the return line through which the good ammonia was to pass back into the system.

Anything that did not evaporate at 75 to 80 deg. temperature was drawn out and thrown away. The ½-in. return gas line was extended up till it was 3 ft. above the top of the suction line at its highest level where a bend was placed and the ½-in. line connected into the suction line. The bend prevented oil or moisture entering the line. The three 1-in. drains were connected together and the line extended down and connected into the 1-in. opening provided in the receiver. The three 1-in. drain valves on the ells of the suction lines and the ½-in. gas return valve were left wide open at all times unless in case any changes were being made that necessitated their being closed.

Oil and moisture, flowing along the bottom of the suction lines would drop into the 1-in. lines and pass on to the receiver. The good ammonia that was contained in the oil and moisture would evaporate at the temperature of the uninsulated receiver and pass through the ½-in. line to the high point of the suction line.

For some weeks after being installed this simple ammonia purifier was emptied every 3 or 4 hr. and for some time between 15 and 20 gal. of oil and moisture was drawn out during 24 hr. This amount gradually decreased and finally the receiver was emptied about twice a week; however, it was kept in constant use, for it required practically no attention.

Using India Ink in an Ordinary Fountain Pen

By N. G. Near

THAT India ink cannot be used in an ordinary fountain pen is the general belief. That belief, however, is incorrect as I have been lettering and writing with India ink from the same fountain pen for over a year and have no trouble. The principal thing to look out for is—keep the ink flowing and do not allow it to dry up. In other words, keep the ink moist.

When I first began using an ordinary fountain pen in this way, I plugged the holes in the cap with wooden plugs and always fitted the cap down tightly on the barrel of the pen. By keeping the holes plugged, I had no difficulty whatever but it was rather inconvenient to keep the pen in a handy place because of the danger of knocking the plugs out. I therefore devised a better method and that is simply to put the fountain pen in a corked test tube. The test tube should contain a little water so that the atmosphere within the tube will always be moist. There will then be no danger of the ink drying out.

One thing to avoid is—don't change from regular writing fluid to India ink, without first giving the pen a thorough washing. Ordinary fountain pen ink and India ink do not mix well. When mixed, they seem to form a solid or precipitate which clogs the pen.

Mechanical Forced Feed Lubricators

PROBABLY FOR the reason that mechanical forced-feed lubricators are within themselves a lubricating device, they are often not given the attention and care which they require.

In the first place, a lubricator should not be installed until the instructions which accompany it are carefully read and understood. It will always pay to spend a little time to study the point at which the lubricator should be mounted and how it can best be connected up to some moving part of the engine.

Lubricators of this kind should be securely fastened to a plate angle shelf which in turn should be fastened to the engine casting by steel bolts. Avoid placing the lubricator where the oil will become heated and boil, causing it to gas. Locate the lubricator so as to get a straight line motion and to avoid a side thrust on the driving mechanism. A vacuum check valve should be placed at the main steam header and ⅛-in. pipe run from it to the pump or lubricator. Extreme care must be taken to blow out all pipe before it is finally hooked up. Some pumps are provided with a heater connection at the base of the oil reservoir for passing live steam through when the pump is operating at low temperatures.

It is convenient to place a union in the coil pipe near the pump. The sight feed may be placed at any convenient place in the pipe line but it should be installed so that the arrow on the body points away from the pump. When the pump has been placed in position, fill it with oil, disconnect the union at the vacuum check valve and operate the plunger by hand until oil flows from the union, which may then be connected up again. If the pump should become empty, it will become air bound. It will then be necessary to slack up on the stuffing-box until oil leaks from around the stuffing-box.

Always put oil in through the strainer so all trash will be removed. If the oil is too heavy to pour in extremely cold weather, it will be necessary to warm it. Keep reserve oil in a warm place for convenience. It must not be forgotten that there are certain parts of the lubricator which must be oiled occasionally. The plungers are generally supplied with a special packing, although ordinary wick packing will do in an emergency. A wrench should not be used to tighten up the stuffing-box gland, tighten it only with the fingers.

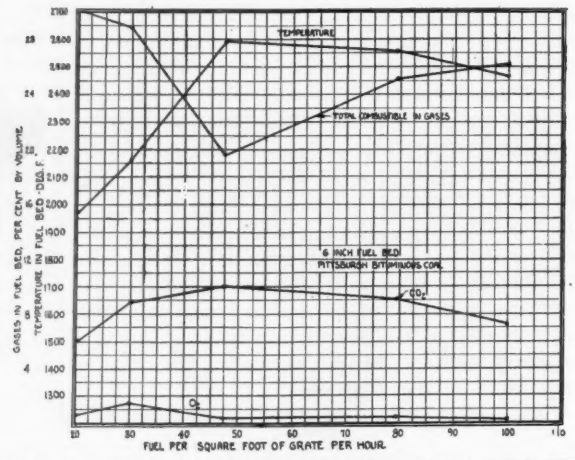
Leaking plungers are an indication of excessive pressure required to drive the oil through the line. It often means that scale or other foreign matter has collected at the check valve or in the pipe. To relieve this condition, hold the check valve open and allow steam to rush through it, also blow out the pipe with steam. Leaking plunger stems may be caused by wear resulting from the stuffing box being drawn up too tight or the wrong kind of packing being used.

After six to twelve months service, it sometimes happens that oil precipitation and sediment have collected in the bottom of the reservoir. This should be removed and the reservoir blown out with a steam jet.

All pumps are given a shop number by the manufacturer. It will save much time and confusion if this number is given each time that repair parts are ordered.

To Regulate Fuel Expenses, Control Draft

I WAS interested in reading an article on the regulation of fuel expense by draft control, by James T. Beard, on page 331 of the March 15 issue of Power Plant Engineering, because this article, while restating some of the elementary text book data on losses due to excess air, also gives expression to a number of ideas regarding furnace operation which are held by a number of power plant men and which the writer believes to be wrong.


TEMPERATURE
TOTAL COMBUSTIBLE IN GASES
6 INCH FUEL BED
PITTSBURGH BITUMINOUS COAL
CO_2
O_2
GASES IN FUEL BED, PER CENT BY VOLUME
TEMPERATURE IN FUEL BED - DEG. F
FUEL PER SQUARE FOOT OF GRATE PER HOUR

INVESTIGATION OF COMBUSTION PROCESSES IN A FUEL BED

Mr. Beard states, "To burn the coal at all, air must be supplied to the fuel bed. The resulting combustion develops a given temperature in the furnace. If too much air is supplied, the furnace is cooled down. The quantity of air for best economy depends upon the thickness of the fuel bed." The accompanying graph shows the effect of the rate of combustion upon the composition of the gas leaving the top of a live fuel bed, resulting from the burning of bituminous coals. The curves show the results of tests made by the Bureau of Mines and are reported in Technical Paper No. 137. The authors of the paper state that "Within wide limits, the rate of feeding air has practically *no effect* on the composition of the gases within the fuel bed"; that is, the composition of the gases at various depths in the fuel bed remains the same or nearly so no matter how much air is forced through the fuel bed. Although the tests above referred to were made in an experimental furnace having a uniform live fuel bed, the conclusions drawn will apply to actual furnace conditions where the fire is uniform, if it is assumed that that portion of the total air supplied for combustion which passes through the live portion of the fuel bed is constant at all rates of combustion.

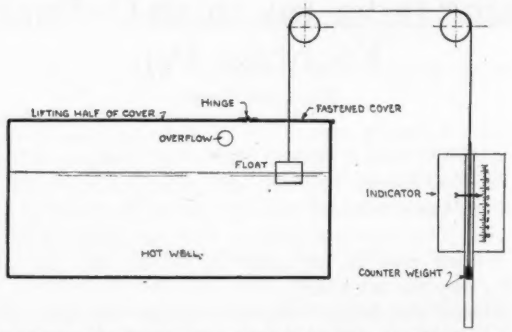
From a consideration of these statements, it should be seen that there will be no reduction in furnace temperature with an increase in air flow through the fuel bed. In fact, due to the reduction in amount of heat given up by radiation from each pound of gas passing through the furnace with increased rates of combustion, the furnace temperature is actually higher. If the high rates of combustion are maintained for any great length of time, it will be necessary, of course, to increase the rate of coal feed in order to maintain the same amount of live fuel bed area and furnace temperature.

In Figs. 4 and 5 of Mr. Beard's article he represents the fuel loss due to operation with CO_2 percentages lower than the assumed value of 14 per cent to be proportional to the difference between 14 and the actual CO_2 percentage. To one familiar with equations expressing the relation between per cent CO_2 and weight of air per pound of carbon burned, it will be evident that the loss does not vary directly with the difference in CO_2 percentage.

Springfield, Pa. CHARLES E. COLBORN.

Hot Well Should Have a Water Level Indicator

LARGE NUMBERS of small power plants still use the open hot well having a sheet iron cover which has to be raised every time the fireman desires to see the height of



SIMPLE WATER LEVEL INDICATOR FOR A HOT WELL

the water in it. Usually a lot of hot water is allowed to go to the sewer via the overflow from such hot wells where the condensation is considerable. Some kind of indicator should always be used to show the height of the water.

Where proper methods are not used to remove the oil from the condensate, a certain amount will collect in such hot wells. By allowing the tank to overflow occasionally, much of this oil will be carried to the sewer. Knowing this, the fireman is likely to let the overflow do overtime work, using cold water for make up. This is a costly process in two ways.

When there is no indicator the operator is likely to pump the hot well empty and if there is any oil on top of

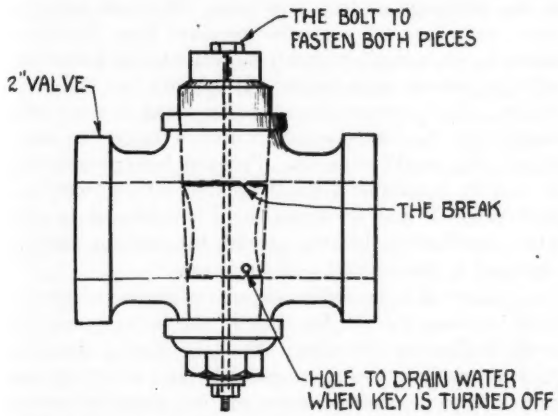
the water it will be carried over into the boiler every time this is done.

The accompanying sketch shows one arrangement that can be set up in an hour or two at practically no cost. The float can be made out of a tin can and the pulleys and cord will not cost more than a quarter of a dollar.

Toronto, Ont. JAMES E. NOBLE.

Repair of a Cutoff Cock

DURING A bad cold snap recently, the stop cock of a water tank was shut off during the night and the key froze and broke, letting all the water run into the sewer.



THE TWO HALVES OF THE BROKEN KEY ARE HELD TOGETHER BY A BOLT

Since no other valve was at hand to replace it, and as the job would have involved considerable pipe work, the key was drilled through and a ½-in. bolt inserted to hold the two halves together. A ⅛-in. hole was also drilled through the side of the body to drain off the water left in the key to prevent a repetition of this occurrence. The key with the bolt through it can be turned as before and will suffice until the weather permits a replacement. In all other service cocks we have drilled a small drain hole through the side of the body as a protection against freezing.

Pahrump, Nevada. CHAS. LABBE.

Doing Away with Licensed Firemen and Engineers

UPON TAKING a position as engineer for a firm handling cotton, wool, flannel and silk by-products, I was shown the steam plant which consisted of a 72-in. horizontal return tubular boiler, one duplex boiler-feed pump and a gravity return heating system. The owner told me I was to keep the building warm 24 hr. a day, and also furnish steam to another tenant in the same building and supply him with ample steam for several steam kettles and for boiling purposes.

I succeeded in complying with his requirements while I was employed there. After about a month of service, the owner called me into his office one morning and showed me a new 1½-in. Lock pop safety valve, saying he wanted me to place this device on the boiler instead of the regular 4-in. safety valve which was set to blow off at 25 lb. My grate was 5½ by 6 ft. which gave me 33 sq. ft. of grate area.

After telling him that a 1½-in. Lock pop safety valve was not large enough, he asked how large a valve was needed. I told him I would figure it out and let him know. The next morning I informed him that according to the Massachusetts Steam Boiler rules, we would have to employ a 4½-in. Lock pop safety valve if we use the bevel seat type; or a 4-in. flat seat type but I did not recommend the flat seat type.

A 4½-in. Lock pop safety valve bevel seat type could not be purchased in our locality so we placed a 4-in. and a 2-in. on a tee fitted from the nozzle of the boiler.

After this was accomplished, I was called into the owner's office and told that in the future the pressure would be reduced from 25 to 15 lb. and there would be no need of a regular engineer.

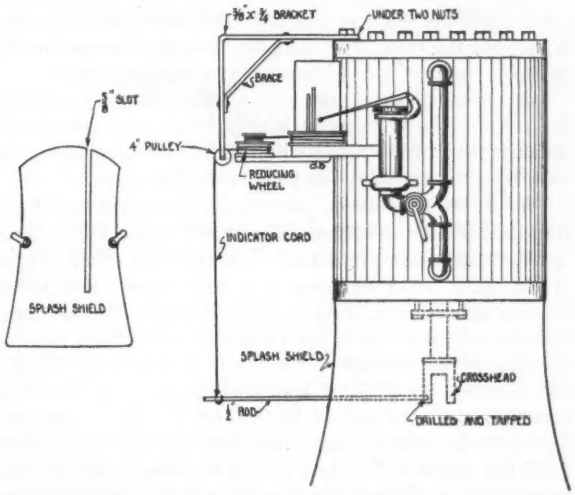
May I ask my fellow engineers, is this the proper spirit for public safety? Can any Tom, Dick or Harry be hired to take the place of the engineer and insure absolute public safety?

Can the foreigner they hired at approximately one-half the engineer's compensation, who has never seen a steam boiler in his life, cope with all the usual power plant obstacles?

Springfield, Mass. ERNEST E. CLARK.

Improvised Indicator Rigging

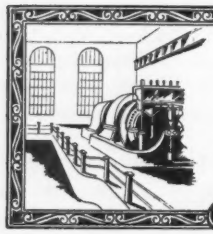
IN AN isolated steam plant in New York, a vertical engine was installed to take care of a small night load. No provision had been made for indicating the engine. After a time it was deemed advisable to take some diagrams from the cylinder. Holes, ½-in. pipe size, were drilled and tapped at the ends of the cylinder and the necessary piping and a two-way indicator cock were connected up. The



ADAPTING A SMALL ENGINE TO THE USE OF AN INDICATOR

engine was self-oiling, and had removable splash-shields attached to each side of the housing. There was barely room on the crosshead for a hole for a ½-in. stud but in a lower corner we tapped out a hole. A long slot was made in the splash-plate for the stud to travel in. A bracket of ⅜ by ¾-in. steel was made to hook under two of the cylinder-head nuts. This bracket supported a 4-in. wheel, for leading the indicator cord to the stud. The engine ran at 275 r.p.m. and there was considerable vibration, but with this arrangement we were able to get some quite satisfactory diagrams.

Utica, N. Y. M. M. BROWN.

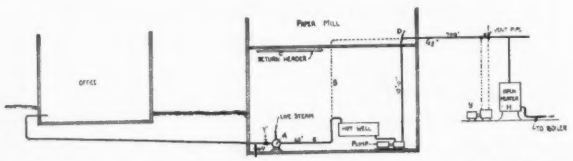


QUESTIONS AND ANSWERS

Forced Draft Fan or Higher Stack; Are Traps Applicable Here?

REPLYING TO F. S. on page 203 of the Feb. 1 issue, on the advisability of renewing the top 40 ft. of the stack and installing a forced draft fan, I must say it would not appeal to me as being the best method. The short stack would not carry away the gases from the furnace as rapidly as produced by such a forced draft fan and gases would escape into boiler room.

To me it would seem advisable to install an induced draft fan between the boiler and the stack. This has the advantage of keeping the gases out of the boiler room (the



SUGGESTED PLAN FOR RETURNING CONDENSATE TO BOILERS

fan can be speeded up to increase the draft through the grate much the same as with a forced draft fan) and also to increase the velocity of the gases through the short 30-ft. stack.

One great disadvantage with a forced draft or induced draft fan is the slowness in raising steam on a cold boiler sufficient to run the fan or the inability to keep steam up on a boiler if anything happens to the fan engine.

W. J. M.'s question concerning the applicability of traps to his heating system on page 203 of the Feb. 1 issue is somewhat lacking in detail. A better idea of the piping of his plant could be given if it were known how much heating apparatus is being used, the amount of steam pressure on each and the boiler pressure carried to give some estimate of the volume of returns to be handled. He did not mention the kind of trap that he tried on the office return line, or the size of the piping, or how it was connected to the hotwell tank. The fact that the trap had to raise the water 9 ft. when only 4-lb. steam pressure was being used on the heating apparatus in the office building is sufficient reason why the trap did not work. It was probably an ordinary drain trap and after dumping three or four times the pressure was equalized on both sides of the trap. The friction of the pipe line plus what pressure may have been in the hotwell tank (he did not mention whether it had a vent pipe or not) was enough to overcome the pressure in the heating system. A return trap installed at A in the accompanying sketch, if connected to a high pressure steam supply line would have sufficient power to raise and discharge the condensate from the office return line to the hotwell and still use the 4-lb. pressure on this part of the heating system. It would also keep the condensate up to a high temperature which may give trouble due to steam accumulation in the hotwell tank. To feed the boiler 15 ft. above the floor would require boiler pressure plus about 7½ lb., due to the lift, plus the pressure required to open the check valve and overcome the friction of the discharge or feed pipe line. The feed pump will force water against a greater pressure than that in the boiler, hence it would probably be better to use a feed pump with the present open heater. It appears that the present 2½-in., 700-ft. return to the boiler room is too small to handle all the condensate and that a larger or another 2½-in. line would be needed. Probably better results could be had by installing a small vacuum return pump at A with valves V and V^1 which could be operated as needed when overhauling the trap or with the vacuum pump discharging to the hotwell tank or to sewer.

I assume it is desired to dispense with the present pump used to pump the returns back to the boiler room. This could be done in two ways: First, by placing the hotwell tank as near the ceiling as possible, and using the boiler return traps to raise the water up to it from the low pressure apparatus. This hotwell should be sealed tight with the system and a relief valve provided to prevent an excess pressure on the tank. Or, second, by connecting all returns to a large header located at the dotted lines C and using a boiler return trap at A and a vacuum pump G in the boiler room, with about 22 to 25 in. of vacuum the pressure from the trap would aid the vacuum to get the condensate to the boiler room. The steam used in the trap would help to keep up the temperature of the returns, or if the returns were too hot, just enough jet water could be used at the vacuum pump to keep it cool enough for the pump to handle satisfactorily.

The dotted line B would be optional depending on which system was used. If a vacuum pump were used at A and the hotwell tank removed, the pump would have to discharge against whatever pressure there was in the return line. This pressure may be overcome even with the present system by selecting a special vacuum pump so designed as to maintain a vacuum and pump against a slight pressure at the same time.

If a vacuum system is installed it may be necessary to put vacuum return valves on the radiators or vacuum traps on branch return lines or a stop valve in the main return line which can be throttled down to prevent steam pulling through.

Cambridge, Mass. R. A. CULTRA.

Refrigeration Plant Operation

UNDER the caption "Refrigeration Plant Operation," on page 203 of the Feb. 1 issue, I note that J. B. asks some questions in regard to charging his system. When charging the anhydrous in a system it is usual just to close the main receiver valve then open the valve on the drum. As he is charging through the evaporating coils, or brine cooler, the drum acting temporarily as the receiver, it is correct to open the valve wide on the drum and when

the noise of the ammonia flowing through the piping ceases, the drum can be considered as empty and should be immediately closed off, otherwise there is danger of the liquid reversing its flow and going back into the drum again.

It is not necessary to pump down to atmosphere or a vacuum, as there is so little ammonia in the drum at 15 lb. pressure, that it costs more to pump out than it is worth.

Ordinarily the expansion valves can and should be opened much wider than usual so as to charge quickly and cause no delay or loss of temperature but if you do not care to disturb the setting of the expansion valves, you can charge just the same; however, it takes a few moments longer.

When the system needs a new charge it will show up in the receiver. J. B. should have from 8 to 12 in. of liquid in sight in the gage glass when his plant is operating normally. All coils should be frosted back nearly to the machine. Always keep a liquid seal in the receiver to prevent gas from getting past the receiver valve.

To pump out his ammonia receiver so as to make repairs on it is a simple matter. Close the valve on top of the receiver, open wide the receiver valve so as to allow all liquid ammonia to pass to the expansion coils, pump a slight vacuum on the evaporating coils, then close all the expansion valves, and shut down the machine. He can then get all the gas out from receiver by attaching a pipe to the charging valve and allowing this gas to be absorbed in a pail of water, then he can make any repairs necessary to the receiver. When the job is finished, he can get all the air out of the receiver by opening the valve on top of the receiver slightly, allowing the air to flow out into the same bucket. When a crackling noise is heard, all the air is out and he can close the valve. Watch the receiver for leaks; if none are found, open the top valve wide, go around to all expansion valves and set them, then start up in the normal way.

It is possible to charge direct to the compressor cylinder if there is a valve there but it means watching the machine for a possible freezeback.

My advice is to pump down below atmosphere as few times as possible to avoid getting air in the system. Purge

New York, N. Y. D. L. FAGNAN.

Utilization of Exhaust Steam

IN THE Jan. 15 issue on page 157, in an article in reply to E. W. M.'s question on page 1105 of the Nov. 1, 1923 issue, R. A. Cultra states that "To have the condensation return properly from the end of the 250-ft. suction line, would require from 18 to 20 in. of vacuum, and even then the steam must not be permitted to enter the return main in such volume as to destroy the vacuum or overtax the capacity of the vacuum pump." I agree with the latter part of this statement but not with the first. I have demonstrated to my satisfaction that condensation will return from the farthest point of a 375-ft. vacuum return line, with a vacuum of 10 to 11 in. at the pump.

Seven years ago, I rebuilt an old gravity heating system into a vacuum return system. The amount of money that could be spent on the job prohibited any increase in the size of the supply mains, on which from 5 to 18-lb. pressure used to be carried prior to the change. Thermostatic traps of the expansion type were installed on the return pipe of each individual heating coil or radiator. These traps, as experience demonstrated, would not stand a total pressure of over 15 lb., before the expansion element would break down and either come through the return line or stop up the traps so that the radiator would fill with water. A little experimenting demonstrated that a vacuum at the pump of 10 to 11 in. and a supply pressure of not to exceed 4 lb., would do the job of heating all right, keep returns free from water of condensation and not damage the traps. This particular return line is without grade from end to end but the pump is about 18 in. higher than the main, where it is connected to the pump.

Ordinarily no water is turned into the return line, although a ½-in. line was provided so that a cooling spray could be used if required. About 175 ft. from the pump, there are radiators whose discharge is only 2 in. higher than the vacuum line. At any time the vacuum pump is running we can shut the supply line to one of these radiators and open the trap and find no water in radiator or vacuum return line. Of course a real honest to goodness vacuum heating system is not supposed to have to carry any considerable pressure on the supply mains and should be supplied with traps on the return end of radiating apparatus that will stand a pretty high vacuum but quite a number of engineers are up against the same proposition that I was, i. e., being furnished certain kinds of material and expected to get results. In this way I discovered that there are certain types of thermostatic traps that will not stand for high vacuum, where you have to carry pressure on the supply mains, on account of their not being of sufficient size to supply the volume of steam required, at low pressure.

Minneapolis, Minn. FRED S. RUTLEDGE.

Proportioning Heating Costs; Is the Fan at Fault?

J. W. C.'S QUESTION on proportioning heating costs in the Feb. 15 issue is a better basis, on the data furnished, for a guessing contest than for engineering calculations as the figures he asks for would require a rather detailed knowledge of the plant equipment and operating conditions.

However, for an estimate, which has worked out fairly well in practise, direct radiation will under the usual conditions condense about ⅓ lb. of steam per sq. ft. per hour and indirect radiation, when the fans are running, about ½ lb., hence, for the 30,000 sq. ft. of direct surface and 10,000 sq. ft. of indirect, the total steam consumption would be $30{,}000 \div 3 + 10{,}000 \div 2 = 15{,}000$ lb. per hr.

Assuming an actual evaporation of 9 lb. water per lb. coal, there would be required 111 lb. of coal per 1000 lb. of steam, which at $7.50 per short ton, would cost 41.6c per 1000-lb. steam for coal, and it has been found that for ordinary small plants this will comprise about 60 per cent of the total cost of the steam. Hence high pressure steam would be worth about $41.6 \div 0.60 = 70$c per 1000 lb.

The relative cost of high and low pressure steam is a matter for separate calculation for each individual installation. As a rule, the cost of low pressure steam may be figured as equal to the increased cost of supplying low pressure steam over the most economical method of operation when not furnishing it. With engines normally operating non-condensing the cost of supplying steam at 2-lb. gage would be comparatively small, probably not over 3 to 5 per

cent of that of high pressure steam but if operating condensing engines or a bleeder turbine, particularly at part load, the relative cost may be 30 to 50 per cent of that of live steam.

It may seem rather a paradox that the more efficient the apparatus the higher the cost of low pressure steam but since this is rather an accounting figure than an actual loss, the whole plant economy will be materially improved by the smaller quantities of high pressure steam required.

Referring to P. D.'s inquiry in the Feb. 15 number, "Is the Fan at Fault?" the data given is not sufficient to say definitely but we may assume certain conditions which P. D. can correct to meet his requirements.

First we assume that the boilers are operating at rated capacity giving a total of 425 developed hp. Taking rice coal having an ash content of 30 per cent and a heating value of say 10,000 B.t.u. per lb., this would give, with 55 per cent overall boiler efficiency, an average combustion rate of 23.4 lb. per sq. ft. per hr. requiring at least 1.10-in. water pressure in the ashpit. If good fires are carried it should be possible to average 11 per cent CO_2 representing about 60 per cent excess air, in which case each cubic foot of air would develop about 59 B.t.u. in the furnace and at 30-in. barometric pressure and 65 deg. F., the usual fan standard, a flow of 7350 cu. ft. per min. would be required.

Assuming further that the fan dimensions shown are for the wheel, these figures will correspond closely to a 60-in. steel plate fan, which, driven at 800 r.p.m. should, when delivering this quantity of air, give over 3½-in. static pressure at the outlet of the fan.

The ducts appear rather small; the main duct, 19 by 24 in. having 3.16 sq. ft. of cross-sectional area gives a velocity of 38.7 ft. per sec. compared with a desirable figure of about 20 ft. per sec. Assuming the air divided in proportion to the rated horsepower of the boilers, the velocity in the 20-in. terra cotta duct would be 36.4 ft. per sec., in the 16 by 18-in. inlet to the first boiler 21.6 ft. per sec. and in the 12-in. terra cotta pipes to the other boilers 46.0 and 55.0 ft. per sec. respectively. From this it would appear that the flow into these latter boilers is badly restricted but this could easily be checked by setting the fan to run at constant speed and measuring the pressure in the different ashpits with the wind dampers fully open.

It may be also that there are enough air leaks in the brick duct and around damper openings to give the impression of insufficient capacity on the part of the fan. Such experiences are not unknown even in new and apparently tight concrete ducts in modern power stations.

It is also more than possible that part of the trouble is due to the large percentage of air space in the grates of the 150-hp. boilers. It has been found in burning small anthracite or, in fact, any other fuel with high air pressure, that the percentage of air space must be kept low enough so that if the fire starts to burn thin in one place the grates will act as a slow restricting orifice and keep all the air from escaping at that point, burning out the fire there that much more rapidly and reducing the air pressure and rate of combustion at other points.

I would therefore recommend to P. D. that before scrapping the fan, which has a capacity of 12,000 cu. ft. per min., against a 2-in. static pressure or 11,000 cu. ft. against 2½-in. static pressure, he investigate his combustion conditions with the V mesh grates and take air pressures along the duct from the fan outlet to the boiler ashpits. Undue restrictions in the area will be shown by corresponding drops in pressure. Remedying these defects will probably solve the difficulty.

New Haven, Conn. H. D. FISHER.

Remodeling Refrigerating System

ANSWERING C. J. R.'s question, on page 254 of the Feb. 15 issue, I would say that it is quite feasible to change his present system of direct expansion to brine circulation for cooling the storage room.

The compressor, a 7 by 10-in. two-cylinder single-acting machine, operating at 60 r.p.m., has a displacement of $38.48 \times 10 \times 2 \times 60 = 46{,}176$ cu. in. Assuming a volumetric efficiency of 80 per cent, the actual displacement available is $46{,}176 \times 80 = 36{,}940$ cu. in.

Under standard conditions of 165-lb. condenser pressure and 20-lb. suction pressure, a ton of refrigeration requires the pumping of 6990 cu. in. of gas per min.; therefore $36{,}940 \div 6990 = 5.28 + T$, refrigerating capacity per 24 hr.

The refrigerating capacity that the proposed changes will require may now be calculated. Assuming that the insulation of this cooler is good and is equal to 2 in. of nonpareil corkboard, we can use a heat leakage factor of 3 B.t.u. per sq. ft. of exposed surface per degree difference of temperature between the outside and inside of cooler. The exposed surface of the cooler is $15 \times 8 \times 2$ plus $15 \times 6 \times 2$ plus $6 \times 8 \times 2 = 516$ sq. ft. Assuming 90 deg. outside temperature and 40 deg. in cooler, we have a temperature difference of 50 deg. F.

The heat loss is then $516 \times 3 \times 50 = 77{,}400$ B.t.u. per 24 hr.

The average stored meats and produce in a cooler of this kind come to the storage in a comparatively cool or chilled condition and do not require a great amount of refrigeration. In this case we will assume about 50 per cent of the heat loss as the refrigeration required to hold the temperature at 40 deg., or the removal of 38,700 B.t.u. per 24 hr.

Thus 77,400 plus 38,700 plus 10 per cent more for opening and closing of cooler door gives a total of 127,710 B.t.u. $127{,}710 \div 288{,}000 = 0.44$ T.

Instead of adding twenty 100-lb. cans and the necessary brine tank, I would suggest that a standard 2-T. ice-making tank be installed. A standard 2-T. tank would contain sixty 100-lb. cans ($8 \times 15 \times 33$ in.) and the tank dimensions would be approximately 17 ft. long by 6 ft. wide by 3 ft. deep (5 cans wide and 12 cans long). This tank should have 644 ft. of 1-in. pipe or 544 ft. of 1¼-in. pipe arranged in 7 coils each about 15 ft. long.

This size of tank would hold a large amount of brine which, reduced in temperature, would allow the compressor to be shut down for certain periods. The brine circulating pump operating 24 hr. will take care of the cooler.

Under standard conditions 11,184 cu. in. of gas must be pumped per minute per ton ice making. Harvesting one ton of ice per day will require 11,184 cu. in. per min. compressor displacement and to refrigerate cooler 3075 cu. in. per min., a total of 14,259 cu. in. per min.

As the refrigerating requirements are 14,259 cu. in. per min. and the compressor has 36,940 cu. in. displacement per min., we have ample compressor capacity for the amount of work required.

The size and number of feet of brine piping to cool the storage room can be found by using the following rule: 1 lineal foot of 1¼-in. pipe per 5 cu. ft. of space for a temperature of 40 deg. with 15-deg. brine, for 24-hr. operation.

As this cooler has 720 cu. ft. space, then $720 \div 5 =$ 144 ft. of 1¼-in. pipe will be required.

I would suggest using 150 ft. of 1¼-in. pipe arranged in two coils containing 75 ft. of pipe, each, hung one coil on each side of the room, running the long way, top pipe of coils to be at least 8 in. from ceiling.

I would connect these coils in parallel with inlet and outlet valve on each coil. The coils should be of continuous bent pipe in preference to made-up coils of pipe and return bends. In either case, for long life and economy, the coils and hanger and fittings should be galvanized.

The best insulation that I have found for cold pipes exposed to the weather is hair felt applied with tar. First cover pipe with tar paper, then a layer of 1-in. hair felt, well wrapped with string, tar this well all over, apply another layer of hair felt, wrap well with string and tar all over. Apply a layer of absorbent building paper then a layer of tar paper and the outside of this can be covered with canvas well painted or preferably wrapped with heavy roofing paper. I have seen lines covered in this manner that have withstood the elements for 25 yr. or more.

Regarding a brine pump for this installation, I think it is advisable to have a pump with a capacity in excess of the coil requirements, due to the long lead from brine tank to cooler. A centrifugal pump of 10 g.p.m. capacity, direct connected to an electric motor is the most satisfactory unit I know of for this purpose and is ample size for the requirements.

The suction of this pump should be taken from near the bottom of the ice tank at one end and the return brine from the cooler should enter the brine tank at the opposite end, being sure to have the end of brine return pipe submerged to prevent excessive corrosion in the pipe work.

Chicago, Ill. C. E. Anderson.

Steam Consumption of Drier

Referring to M. D.'s question regarding the steam consumption of a drier, I would say that, unless there are unusual conditions to be met, the radiation of such coils can be calculated quite accurately as a great deal of experimenting has been done along this line. Neglecting the area of the return bends, the surface of the two coils, containing $2 \times 6 \times 20$ ft. or 240 lineal ft. of 1¼-in. pipe, 2.301 ft. of which give 1 sq. ft. of surface, will be 104.3 sq. ft. These coils, at 100-lb. steam pressure will have a temperature of 338 deg. F. and the temperature difference between this and the room temperature of 160 deg. will be 178 deg. F. Experiments on radiation of bare pipe in connection with insulation value of various coverings show that under such conditions the radiation will be 2.55 B.t.u. per sq. ft. per deg. difference of temperature per hour, or possibly a little more on account of the high temperatures of both pipe and room. Taking this value, the radiation of the coils will be $103.4 \times 178 \times 2.55 \times 6 \times 24 = 5{,}400{,}000$ B.t.u. per week of six 24-hr. days. If the condensate from these coils, at 100-lb. gage and about 338 deg. F., is trapped into the heating system return line, the heat above 212 deg. F. will go to heat the other condensation in that line, so it seems hardly fair to assume the 9.25-lb. evaporation per lb. of coal as referring to steam evaporated at 100-lb. gage and returned to the boiler at 338 deg. F. but rather to steam generated at 100-lb. gage and say 1 per cent moisture from feed water at 210 deg. F. On this assumption the heat content of the steam will be $1190.6 - 8.8 - 178.0 = 1003.8$ B.t.u. per lb. (a factor of evaporation of 1.036) which, with 9.25 lb. of steam per lb. coal would require $5{,}400{,}000 \div (1003.8 \times 9.25) = 581$ lb. coal which at $10 per short ton would cost $2.90.

A fair cost for steam under such conditions, when a small additional amount is required from a plant already operating, is to take the fuel cost as 60 per cent of the total selling price of the steam which would make the charge for the steam for these heating coils $\$2.90 \div 0.60 = \$4.83$. If the $24.00 operating expense mentioned all applies to this one small piece of heating work, it would seem that some other source of heat would be more economical.

For instance, to supply 5,400,000 B.t.u. by electric heating, since 3412 B.t.u. equal 1 kw.-hr., would require $5{,}400{,}000 \div 3412 = 1583$ kw.-hr., so that, if the total cost of the heating at present is $\$2.90 + \$24.00 = \$26.90$, a rate of 1.7c per kw.-hr. would put electric heating on an equal basis. This would be an unlikely figure where coal costs $10 per ton but it is possible that if no other heating is required a small automatically controlled boiler operated on city gas could be used. For instance, taking gas at 550 B.t.u. per cu. ft. $1.25 per thousand feet and assuming 60 per cent operating efficiency, then the cost would be $5{,}400{,}000 \times \$1.25 \div (550 \times 1000 \times 0.60) = \$20.45$. As this figure is only slightly lower than the greatest possible coal figure, it would mean doubtful economy to make such an installation, owing to the uncertainty of repairs, etc. These figures on other sources of heat are interesting, however, as showing the advantage coal has in cost of furnishing heat and how incidental advantages must be obtained to make any of the prepared substitutes practical on a cost basis.

New Haven, Conn. H. D. Fisher.

Uneven Wear of Steam Piston Packing Rings

Tom Jones' experience with uneven wear on steam piston packing rings as described on page 305 of the March 1 issue is not at all unusual. I have taken rings out of engines and found them worn almost through at a point opposite the joint. Others I have found where the ends were worn entirely away.

The cause of this condition is the sticking of the ring at some point in the groove due to deposits of carbonized cylinder oil; the free portions of the ring then take all of the wear, especially if on the bottom side of a horizontal cylinder. The reason for such a condition is lack of adequate periodical inspection.

Wear on one side of a piston will also tend to cause uneven wear of the packing ring. Whenever the piston rod shows signs of rubbing down on the stuffing-box packing, it is a sure indication that the piston is getting out of round. If a built-up piston is used, it may be recentered by means of the adjusting bolts. At this time the rings should be cleaned and examined. Where a solid piston is in use the crosshead shoe must be adjusted to keep the rod in the center of the stuffing box. If the cylinder is badly worn it must be rebored and a new piston fitted.

Cambridge, Mass. R. A. Cultra.

POWER PLANT ENGINEERING

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Super-Power Interconnection Makes Progress

Like other advances, super-power will best progress by growing to meet the demands of the service to be supplied. Interconnection of systems to transfer power at times of peak load and in emergencies is a logical procedure, will result in saving of fuel and in better service to customers. This is the kind of super-power that is advocated by Secretary Hoover rather than any replacement of existing facilities by new enormous stations or any fantastic plans for locating big stations in places where no adequate supply of condensing water is available.

Such a forward step has just been taken by a group of big power systems serving Ohio, Pennsylvania, Virginia, West Virginia and Maryland, with likelihood that the linking up will soon be extended to Niagara Falls, New England, the Southern Atlantic states, Indiana and Illinois. The companies included in the present agreement are Duquesne Light Co., Penn Public Service Corp'n., Potomac Edison Co., American Gas and Electric Co., Cleveland Electric Illuminating Co., Ohio Public Service Co., Penn-Ohio Electric Co., Northern Ohio Traction and Light Co., Penn Central Light and Power Co., Keystone Power Corp'n., and West Penn Power Co., an imposing array of facilities and organizations.

It is not likely that any power will be transmitted from Virginia direct to Ohio, but any station on the interconnected system can use its spare capacity at any time to supply power to neighboring stations and these, in turn, can pass on power to the ones beyond so that Virginia may transmit to Pennsylvania and Pennsylvania send its released power to West Virginia or Ohio, the effect being that a peak or emergency load in Cleveland is helped out by the capacity of the installations in Virginia.

In other sections of the country, interconnection is growing, notably in California, New England, Northern New York, Illinois, Michigan and Wisconsin, so that it would seem that logical development will, before many years, result in nation-wide interconnection and the operation of the most economical plants at full capacity most of the time, the less economical being used as standbys.

In a smaller way, it would be good engineering for industrial plants and central stations in communities to establish interconnection and current transfer so that the most economical plants shall work at full load all the time, keeping them at the high efficiency region of their prime movers and generators, and the less economical plants be brought into service as there is demand to load them to their points of high efficiency operation. The principle is one of widest application and, since interconnection and load transfer to receive high load factor and high efficiency is sound practice, it is sure to grow in use.

Postal Service Should Be Efficient

Anybody at all familiar with conditions in the post offices of the country will agree that postal employes are justified in their request for better pay. Wages which they receive are not at all in line with those paid for similar kinds of work by private employers and the discrimination is reacting on the spirit and good work of the postal organization. Relief is due and should be provided but this should be done carefully to ensure that justice is done to all postal employes. Bills now before the House of Representatives are not drawn in that spirit. They are hastily

prepared plans and overlook many points which should be considered. Some even are special legislation dealing with individual groups of postal employes and the two bills (H. R. 4123 and H. R. 5552) which are most general in character, omit provision for sixteen classifications of postal employes, as listed by Postmaster General Harry S. New, who should be taken care of.

All classes of employes should be adequately paid; none should be discriminated against; legislation should be based on knowledge of facts and planned to remedy injustices for all employes. This will not be true of hasty, ill-considered legislation.

Deficit in the Post Office Department is estimated for the current fiscal year at $30,000,000. Additional expenditure due to bills now being considered would be $150,000,000, which would increase the deficit for next year to $180,000,000. This would have to be met by increased postal rates or from the general funds of the Treasury, to be raised by taxation. If rates are to be increased, what changes should be made? To answer intelligently, the facts now being secured by an investigation into cost of handling various classes of mail matter are needed. These facts will be available within a few months. Then rates can be adjusted so that each class of mail will carry its fair and scientific share of cost of operating the Department.

If the deficit is to be paid from the Treasury, general taxes must be levied to raise the funds and let nobody fool himself into thinking that he will not pay his share, either in postage or in taxes.

In the blanket bills, many inconsistencies are found; employes in large cities, where cost of living is high, are to be paid the same as those in villages where living is much less costly; in many cases, clerks would receive larger salaries than the postmaster under whom they are working. Such conditions cannot, of course, continue for long and additional patchwork legislation will be the result.

Postmaster General New, who has been studying the whole matter carefully, recommends the submission of all these matters to a Congressional Commission which shall inquire into the merits of all propositions for pay increases, changes in working conditions, cost of operation, postage rates and fees for special services and report promptly, so that all phases of injustice and inconsistency may be eliminated, the employes paid on a just basis, with a reasonable adjustment of salaries to living conditions of employes and cost of operation apportioned to the various services rendered the public.

This plan should have the support of citizens by writing to Congressmen, especially to House and Senate Committees on Post Offices and Post Roads, and by writing to Postmaster General New enclosing his action. The object is, not to prevent or delay increase of the pay of postal employes to an adequate basis but to ensure that all employes are treated justly and that legislation is properly designed to do this rather than being rushed through as a political expedient.

Off Duty

Catalysis is defined by the dictionary as the acceleration of a reaction by the presence of a substance (known as the catalytic agent or catalyst) which in itself appears to remain unchanged.

All of us are more or less familiar with the process of catalysis and it finds useful application in the production of many commodities. Suppose, for instance, that we take two substances in solution which we know should combine but for some unaccountable reason do not. Not being chemists we start to experiment in a haphazard manner. We shake the mixture, heat it, boil it, freeze it; in fact, we subject it to every mechanical or physical action we can think of but without avail. The solutions simply will not combine. Now this is a provoking state of affairs and, being human, we start to cuss and call upon the gods for aid; but also without avail. The solutions appear stubborn and remain unchanged.

In walks a chemist. The situation is explained to him and he appears amused. Taking a small bottle from a shelf in our laboratory, he adds a few drops of the liquid contained in it to our mixture, and, presto! the whole solution froths up. Indeed, so violent is the reaction that some of it spills over the sides of the container. The very thing we have vainly been trying to bring about is happening. The chemist has added the catalyst.

After the reaction the small quantity of substance which brought about the reaction is found at the bottom of the vessel unconcerned and unchanged.

In his delightful little book called "Percolator Papers," Ellwood Hendrick discusses another type of catalyst—a type of catalyst we come in contact with every day but one which we do not always recognize as such. This is the human catalyst. Catalysis, says Mr. Hendrick, is the most social of all phenomena of matter, for human catalysts abound everywhere.

To take an example from Mr. Hendrick's book, let us suppose a number of people sitting around a table on a rainy day. It is a dark, gloomy room and everything is dismal. All are depressed and silent. Then somebody comes in, wants to know whether he may sit down, tells a story, and in five minutes' time he has changed the mental atmosphere of everybody present. The gloom is dispelled and everybody is cheerful. The man who walked in last was a human catalyst.

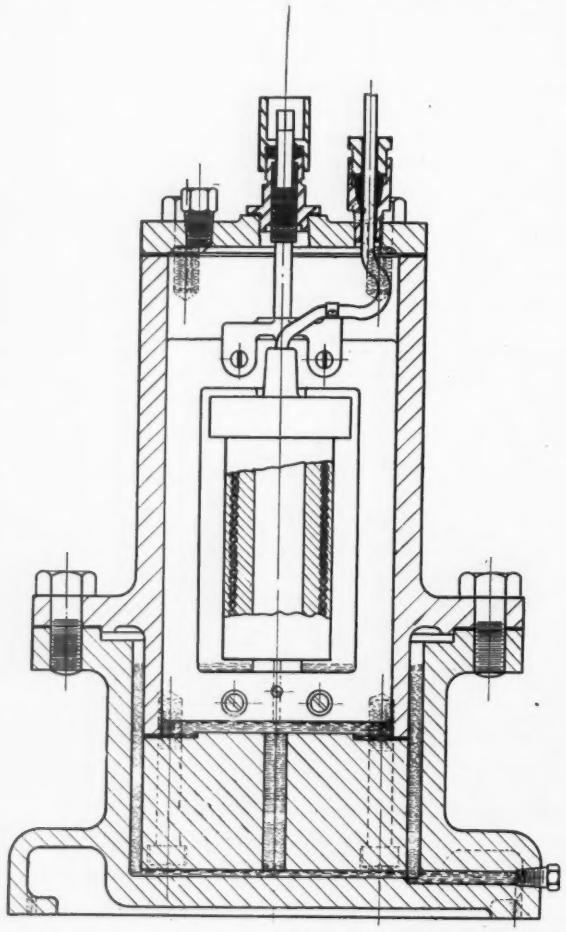
The hostess at a social affair makes use of these human catalysts in making her party a success. In seating her guests at the table she finds there are people with different tastes and temperaments who if seated together would not react socially, so to speak. One, for instance, is a frivolous young lady of modern tendencies while the other is a sedate, serious person of an older school. Obviously, the two would not be mutually agreeable if seated next to each other at the dinner table. So the hostess selects a catalyst —a business man, say, who understands the lighter side of the younger set and who also can engage in serious conversation with a more serious minded individual—and places him between the two. He makes himself agreeable to both and the social reaction is a success. He is a human catalyst.

Now, in human relations as in chemistry, we have positive and negative catalysts. In chemistry, negative catalysts are often useful in retarding certain reactions but in human affairs, the negative catalyst is of doubtful value. We all know persons who by their mere presence create an atmosphere of gloom and depression. It may be that in certain instances they are useful but we prefer the positive human catalyst. The spreader of joy rather than of gloom is the one we like to meet and welcome into our midst. If you are going to be a human catalyst, be a positive catalyst or none at all.

POWER PLANT ENGINEERING DEVELOPMENTS AND NEWS

New G. E. Flow Meter Employs Transformer Principle

IN THE NEW ELECTRICALLY operated flow meter recently put upon the market by the General Electric Co. is provided a means for accurately measuring the total flow of steam, water, air, gas, oil, etc., through pipes.



SECTIONAL VIEW OF G. E. ELECTRICALLY OPERATED FLOW METER

Due to the electrical principle of operation, the indicating, curve drawing and integrating instruments can be located any distance away from the pipe where the flow is being metered. Instruments can be either separated, grouped or arranged as requirements dictate.

There are three principal parts to this meter, the differential pressure producing device, the cast-iron meter body piped to the differential pressure producing device and the electrical measuring instruments mounted on the panel. The cast iron meter body is constructed in the form of a U-tube. Within one leg of this tube is a coil through which the current flows in its path through the meter body and back to the panel. As the differential pressure increases, mercury is forced up around this coil, acting as a secondary inducing more current in the primary. This increase in current is indicated on the electric instruments and, as the differential pressure bears a definite relation to the flow, the current shown on the instruments will likewise bear a definite relation to the flow.

On the outside of the meter body a small transformer is mounted whose function is to reduce the voltage applied to the internal transformer in the meter body as well as to act as an insulating transformer. In series with the primary of this transformer are the adjustable line resistance, voltage regulator resistance and electrical measuring instruments.

When there is no flow of gas or fluid through the main pipe, the electrical instruments indicate the excitation current and the zero readings on the instruments and meters are suppressed so that zero flow corresponds to this excitation current. When the gas or fluid flows through the pipe there is a differential pressure produced by the flow nozzle, causing the mercury in the meter body to rise in the transformer leg and fall in the base until the unbalanced column balances the differential pressure. By proper calibration, the electrical instruments will accurately measure the height of mercury in the small leg of the U-tube containing the internal transformer, which height is a function of the flow of gas or fluid in the pipe.

Water Power Possibilities in Oregon

WITH THE rapid increase in the use of water power and the development of long-distance electric transmission the time is rapidly approaching when the water powers of western Oregon will be as much in demand as the water powers of California are today. An investigation has recently been made to determine the possibility of developing power in the basins of Smith, Trask, and Nestucca Rivers, which are within easy transmission distance of Portland. In the basins of Trask and Nestucca Rivers, the mean annual rainfall is over 100 in. but in the basin of Smith River, less than a 100 mi. to the south, it is considerably less. The slope of Smith River also is less than that of Trask and Nestucca Rivers. The development of power on Trask River to supply Tillamook and on Nestucca River to supply McMinnville has been considered but for the present both cities can probably be supplied more cheaply by the power companies that have already

developed cheaper and more accessible sites on other streams.

No exceptionally good power sites were found on any of these three streams. On Trask River no reservoir sites were found, but by constructing seven low diversion dams and 29 mi. of conduit 23,000 hp. could be obtained for 50 per cent of the time and 4900 hp. could be obtained for 90 per cent of the time. The best power site on Trask River, which would require a low, inexpensive dam and 5 mi. of canal, would yield 1400 hp. for 90 per cent of the time and 6400 hp. for 50 per cent of the time.

On Nestucca River at Meadow Lake there is a small reservoir site which, if developed for storage, would afford 9100 hp. for 90 per cent of the time and 16,000 hp. for 50 per cent of the time, at five sites. These projects would require three low diversion dams and 26½ mi. of conduit. By using the unregulated flow at the best site on Nestucca River, near Silver Falls, a low diversion dam and 5 mi. of conduit would make available 1000 hp. for 90 per cent of the time and 6000 hp. for 50 per cent of the time. If storage is provided in Meadow Lake 3700 continuous horsepower and 6000 hp. for 50 per cent of the time could be obtained at the Silver Falls site.

Little potential power is available along Smith River. Storage could be provided but it would be expensive. With a long dam 140 ft. high to afford storage, 7400 continuous hp. could be obtained by constructing two small diversion

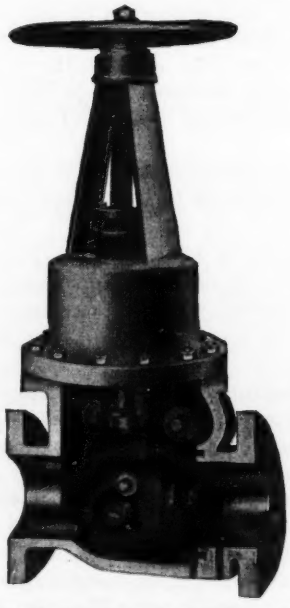


FIG. 1. SECTION THROUGH BORSIG VALVE CLOSED

dams and 34 mi. of canal. Without storage the potential power on Smith River amounts to 400 hp. for 90 per cent of the time and 4500 hp. for 50 per cent of the time.

The total potential power with regulated flow on Trask, Nestucca, and Smith Rivers amounts to 21,600 hp. for 90 per cent of the time and 47,700 hp. for 50 per cent of the time. A brief illustrated report describing the power possibilities of these rivers has been prepared by an engineer of the Department of the Interior, Geological Survey. A copy of the report will be sent to district offices of the Geological Survey for consultation on application to the Director, Geological Survey, Washington, D. C.

The Borsig Valve

THIS VALVE is not a new invention but is something that has been successfully used in Europe for a number of years, in fact, ever since 1913. It is built by the firm of A. Borsig, the largest builder of locomotives in Europe and has a number of extremely desirable features.

It is a straightway valve suitable for steam pressures up to 300 lb. per sq. in. with superheat up to 400 deg. C.

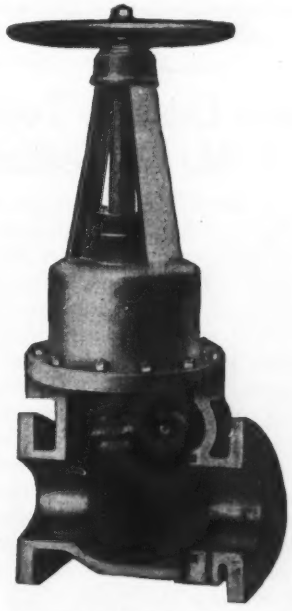


FIG. 2. SECTION THROUGH BORSIG VALVE OPEN

The casing is of cast steel and the valve seat rings of nickel bronze alloy.

There is no appreciable loss of pressure of the steam passing through this valve even at high velocities.

It is claimed that when this valve is used it is possible to transmit steam at maximum velocity enabling the smallest cross-section of pipe line to be installed thus reducing the first cost of the installation and loss of heat by radiation to a minimum. In addition to the advantage provided in the unobstructed passage, it also has the facility as explained before, for regrinding the seat without having to dismantle the valve from the pipe line.

In the following tabulation is shown the loss of pressure due to Borsig valves as compared to various lengths of running feet of pipe line:

Size of valve, inches	Length of piping in ft. which introduces equivalent pressure loss
4	8
5	22
6	11
7	33
8	18
9	37
10	63
11	30
12	50
13	70
14	43

As may be seen from the illustrations, it has a toggle lever action creating a force sufficient to close or open the valve against a pressure of 300 lb. regardless of from which side the steam enters.

When opening this valve, the disc disappears in the bonnet, thereby leaving a straight unobstructed passageway for the steam. Should regrinding become necessary, the valve seat can be ground by simply removing the bonnet and by gradually revolving the disc against the valve seat with an especially fitted key furnished with each valve.

Borsig valves are handled in this country by the Techno-Service Corporation, of New York City.

Furnace Design, Topic at A. S. M. E. Meeting

ON MONDAY, March 24, the Metropolitan Section of the A. S. M. E. met in the auditorium of the Engineering Societies Building in New York for the presentation of papers by E. B. Ricketts and Thomas E. Murray on the general subject of "Boiler Furnace Design." Mr. Rickett's paper dealt with the general subject. That of Mr. Murray, which was presented by John H. Lawrence, Chairman of the Metropolitan Section, was on "A New Design of Water Cooled Wall Construction for Boiler Furnaces," and was supplemented by a discussion presented by W. E. Caldwell of the United Light and Power Co., giving results of tests at different ratings, conducted on boilers having this type of furnace, at the Hell Gate Power Station. All this material will be covered in a later issue of Power Plant Engineering.

Before the more formal discussion of the papers, President Low of the society presented Dr. Klingenberg, President of the Verein Deutsche Ingenieure. The visitor spoke briefly on the present status of power plant design in his country. He referred particularly to a plan in the development stage, by which the functions of the house turbine and the reheating of feed water by stages would be taken care of by one machine for the station, eliminating much of the complication in station piping. He said, however, that two turbines of this kind in a plant would probably be more desirable than one, on account of increased reliability of operation.

Opening the general discussion, John W. Lieb laid stress on the possibilities of increased efficiency through the new types of construction. The evolution of steam generating equipment has brought great improvement in coal burning systems. With the use of powdered coal, the question of selection of the combination to give best results for future plants arises. There will be a radical effect on station economy and investment in plant. If we can satisfy sharp peak conditions, the cost per kw. or per maximum demand can be reduced.

Col. Junkersfeld pointed out that the design of furnaces or brickwork had been of secondary importance until comparatively recently. Each case is unique in itself and must receive study in the light of specific conditions. The significance of water cooling in reducing furnace volume is of wide application. At Cahokia, a single 1890-hp. boiler setting with over 6000 cu. ft. furnace volume requires brick enough for five workmen's houses. This brickwork has proved satisfactory, and a combined boiler, superheater, and furnace efficiency of approximately 85 per cent or more is realized. However, boiler efficiency does not tell the whole story in a comparative sense, unless reduced to an absolutely common basis.

Mr. Webster of the Babcock and Wilcox Company compared the capacities of today with those of twenty years ago, when a guarantee of 150 per cent of rating was regarded as a matter for concern. Today they have installed 9600 hp. in the same space at 59th St. where then they hesitated to guarantee 1800 hp. The boilers at that time had no superheaters and carried 200 lb. pressure, while the new ones are equipped for 350 lb. pressure and 750 deg. F. superheat.

Mr. Lawrence stated that at the maximum capacity test reported earlier coal was burned at the rate of 3000 lb. per retort.

To a question as to figuring of heating surface, Mr. Lawrence replied that one-half of the tubes plus the exposed area of fins is counted—the distance between tubes being three inches.

At the close of the session, John W. Lieb, of the New York Edison Company, complimented the authors upon the excellence of their papers.

Program for A. S. M. E. Spring Meeting

FOR THE Spring meeting of the American Society of Mechanical Engineers which will be held on May 26 to 29, in Cleveland, Ohio, a program of unusual interest to power plant engineers has been arranged. Although the dates have not as yet been assigned, the following is the list of the papers and conferences to be held:

Mercury-Vapor-Process Session: Paper by W. L. R. Emmet.

Conference on Industrial Education, under auspices of A. S. M. E. Committee on Education and Training for the Industries.

Power Problems of Steel Industry (Gas Power and Power Divisions): General Power Problems, Bryant Bannister; Steam Problems, John A. Hunter; Gas-Power Problems—Use of Gas Engine in Steel Works, A. E. Danks.

Materials Handling in Industrial Plants (Materials Handling and Forest Products Divisions); Economics of Material Handling, M. L. Begeman; Continuous Assembly of Automobiles, M. R. Denison; Materials Handling in Tire Manufacturing, W. C. Hoover; Wood Handling from the Railroad Car to the Cut-Off Saw, B. Nagelboort and Thomas D. Perry.

General Session on Windmill and Fan Design: Performance of Centrifugal Fans for Electrical Machinery, C. J. Fechheimer; Wind Power, F. J. Pancratz.

Machine Shop Session (Machine Shop Practice Division): British Machine-Tool Design, W. E. Sykes.

Cleveland Power Session: Pulverized Fuel, Mr. Aldrich; High-Pressure Pumping, L. A. Quayle; Determination of Heat Losses Through Insulating Material, R. H. Heilman.

Joint Aeronautic and Ordnance Session: Aerial Bombing, Maj. A. H. Hobley; The War's Impress on the Steel Industry, A. E. White.

Measurement of Management (Management Division): The Measurement of the Cost-Accounting Function, Messrs. Jordan and Lamb; The Measurement of the Qual-

ity of Product, G. W. Radford; The Measurement of Efficiency of Plant, Equipment and Methods, W. L. Conrad.

Public Hearing on Power Test Codes: Condensers and Gas Producers.

Topical Discussion on Materials at High and Low Temperatures (Joint Session with A. S. T. M.): Industrial Application of Metals at Various Temperatures, L. W. Spring; Methods of Testing at Various Temperatures and Their Limitations, V. T. Malcolm; Available Data on the Properties of Irons and Steels at Various Temperatures, H. J. French; Available Data on the Properties of Non-Ferrous Metals, A. E. White and H. W. Uptegrove.

Tooling and Gaging for Interchangeable Manufacture (Machine Shop Practice Division): Analysis of a Machine-Shop Problem on a Quantity and Final Economy Basis, A. L. DeLeeuw.

Joint Session with A. S. R. E.: Temperature Measurement, P. Nicholls (contributed by A. S. R. E.); Heat Transfer, Edgar Buckingham (contributed by A. S. M. E.).

Recent Developments in Heavy Electric Locomotive (Railroad Division): Paper by N. W. Storer; Paper by W. B. Potter.

Lighting Educational Committee Formed by N. E. L. A.

AS A RESULT of formal action by the National Executive Committee and the Executive Committee of the Public Relations Section of the National Electric Light Association at its meeting in Chicago, on March 14, an educational movement, designed to give the entire public the benefit of the highest scientific and engineering achievements, is assured.

While the details of the plan will not be announced until the convention of the National Electric Light Association in Atlantic City, in May, the movement is sponsored not merely by the National Electric Light Association, but by all the leading organizations contacting with the public in the electrical field. A special committee has been formed, representing the various organizations and groups in the electrical field, and the formal announcement will be made in the name of this committee, which is to be known as the Lighting Educational Committee.

The entire activity is to be non-commercial, the movement having grown out of the desire of foremost men in the industry to give the public a better understanding of the correct principles of lighting.

Government officials and educational authorities have frequently called attention to the lack of general knowledge as to what constitutes good illumination. Conservation of eyesight, through proper diffusion of light in the homes and schools of the Nation, will be one of the features of the general educational movement. James E. Davidson, of Omaha, Nebr., Vice President of the National Electric Light Association, has been named as chairman of the Lighting Educational Committee, and will direct the entire activity. In a statement issued recently, Mr. Davidson said:

"The Lighting Educational Committee will represent the various organizations and groups which individually in the past have been serving the public and siding in the work of education.

"While the complete plan for rendering this educational service to the public will not be announced until the National Electric Light Association Convention, the unselfish support of all the various important organizations and groups is definitely assured.

"The use of electric light in the home has spread in the United States so rapidly that the industry itself feels the need for rendering a more comprehensive educational service that will really assist the public in conserving light and vision.

"The movement will be not merely national, but intensively local as well, and full facilities will be provided for placing at the disposal of the growing generation the knowledge of home lighting that will permit the application of scientific information in simplified, common sense form."

Flow Meter for Use in Small Plants

FOR THE PURPOSE of providing the fireman in the small plant, say of 100-hp. capacity or less, with a reliable means for measuring steam flow, the Republic Flow Meters Co., of Chicago, has recently developed a flow

FIG. 1. THE REPUBLIC R. B. FLOW METER

meter known as the R. B. meter. It indicates to the fireman the load on the boiler.

This R. B. meter system is electrically operated and consists of three parts: the meter body, the boiler front indicator, and the medium used to obtain a differential pressure, either of the pitot tube or orifice plate type. The meter body built of semi-steel is shown in Fig. 1. It is practically a reproduction at a slightly smaller scale of the standard R. S. Republic meter body; it reads accurately to

within 1½ per cent. The boiler front indicator shown in Fig. 2, is 12 in. in diameter and is marked with 1-in. figures, easily read at long range.

With this system the fireman is always kept informed on boiler performance. The R. B. meter shows up lagging or overloaded equipment. If a sudden steam demand impends, the fireman is warned in sufficient time to provide for it, and when the demand drops off, he is similarly warned to curtail steam production.

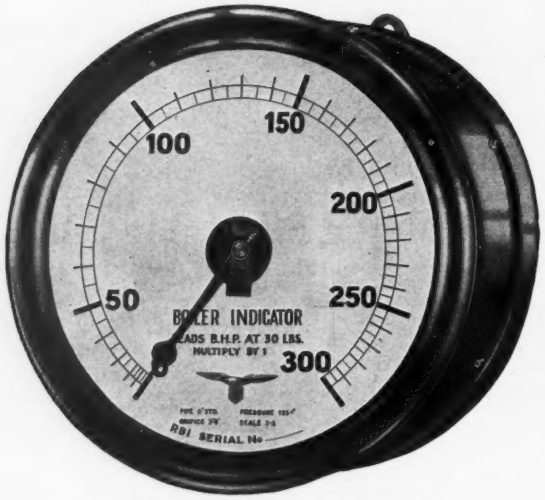


FIG. 2. THE BOILER FRONT INDICATOR

Relation of Heating Boilers to the Smoke Problem

DIRECTOR E. R. Weidlein, of Mellon Institute of Industrial Research of the University of Pittsburgh, has announced an investigation of interest that will involve a scientific study of the relation of low-pressure heating boilers, to the city smoke problem. It is expected that this research will aid materially in solving the problem of boiler requirements for specific purposes, with due consideration to fuel economy and smokeless operation.

One of the sources of smoke is the heating boiler. Manufacturers have designed "smokeless" boilers intended to operate within the limits set by anti-smoke ordinances and great advances along this line have been made within the last few years. In rating the capacities of these boilers, however, manufacturers have not used uniform methods, nor has the information furnished been such that the prospective purchaser can interpret it in terms with which he is familiar, so that he may determine that he is getting what he needs,—not less and not more beyond a reasonable factor of safety.

Boilers have been rated on square feet of radiation and it has been the practice for engineers and contractors to calculate the necessary amount of radiation, then to double this quantity to allow for losses in the line and for a factor of safety. This rule-of-thumb method results, in a large percentage of cases, in providing more boiler capacity than is necessary. Where several boilers have the same rating but perform differently, they will, under the present custom, require the same size stack. This requirement may in one case be entirely satisfactory; it may be insufficient or it may be more than adequate. As a matter of fact, all boilers evaporating the same quantities of water do not require exactly the same amount of coal nor always the same draft.

To enable a prospective purchaser to know what he may reasonably expect in the matter of performance from a particular boiler and what size boiler shall satisfy his needs, the Institute is asking each manufacturer to furnish the certain information concerning the characteristics and performance for each type and size of boiler.

This information will be tabulated for the information of architects, engineers, contractors and prospective users of heating boilers. Proper factors will be included for extreme weather and other varying conditions. It is expected, also to include simple formulas for the determination of the amount of heat required for a building under stated conditions, or the amount of direct radiation which can be figured in terms of the boiler capacity required and the size of the chimney necessary.

There will be no attempt to control design in any way; merely to learn and to tabulate the capacities of "smokeless" boilers together with the conditions under which these capacities may be reached, with the idea of having an installation that is proportioned properly throughout.

Extension of Cumberland County Plant Started

CUMBERLAND County Light & Power Co. of Portland, Me., will start construction work at once on a second unit at the South Portland, Me., property where the first unit was constructed last year at a cost in excess of $1,000,000. The second unit will cost upwards of $1,500,000.

In the new unit there will be installed a 15,000-kv.a. General Electric turbine and three 1240-hp. Heine boilers, to carry a pressure of 275 lb. at 160 deg. superheat. The original unit is equipped with two 6250-kv.a. machines with three 700-hp. boilers.

Oil will be used as fuel, the same as at the present unit; at present there is a storage tank for 1,250,000 gal. of heavy fuel oil. This tank will be duplicated and the tanks are so located that they are readily filled from ships at the company's dock.

In appearance, the plant building itself will practically duplicate the present unit. The structure rests on piles driven 35 to 40 ft. to ledge, with concrete foundations and brick superstructure. Work of clearing the site and driving the piles has already started and the contract is being carried out by the Foundation Co. of New York, contractors who erected the first unit. C. O. Lenz of New York is consulting engineer.

An unusual feature of the plant will be the drawing of water for cooling from Portland Harbor, the plant being built on a neck of land extending a short distance into the harbor. Water is drawn from one side and discharged on the other side of this neck of land so that none of the discharged water comes in contact with the cold water on the other side to find its way back into the condenser.

The new unit will generate at 11,500 v. and distribute to other stations in Portland at that voltage.

Last year the first unit generated 20,368,000 kw.-hr. Last year was a low water year which prevented generating from some of the power plants located along the streams

in the interior of Maine so that the Sputh Portland unit operated nearly every day with a load varying according to water conditions. It was not, however, operated at full capacity.

Last year's consumption of current supplied by the company showed an increase of 14½ per cent over 1922. Between Jan. 1 and Dec. 31, 1923, there was an increase of 4012 meters or from 30,830 to 34,842, a gain of 13 per cent. The highest number of meters carried at any one time was Aug. 31, when there were 35,587. The fact that this figure is in excess of the number reported under the increase is because some of them are for the summer residents only, and are not counted in the annual figures reported. There is certain to be a large increase in the summer residence meters this season. The increase this year is expected to exceed that of last year in permanent meters as well.

Royal S. Holbrook Honored

MEMBERS of the National Association of Stationary Engineers and their friends honored President Holbrook at a banquet at Cedar Rapids, Ia., on March 24, at which Mayor Huston spoke favoring education of more students in the vocations and fewer in the professions. Other speakers were Secretary Davis, who read many telegrams from friends in all parts of the country, besides the bushel or more that he didn't have time to read. C. L. Bland, national deputy, told of the aims of the Association and its motto, "Learn more to earn more." Rev. Hugh Orchard spoke on the subject "The Value and Necessity of Education," showing the importance of engineering to society and the value of the educated man as a citizen and father of future citizens.

In introducing Mr. Holbrook, Arthur Huntington of the Iowa Railway and Light Co. told of the responsibility of the stationary engineers who burn 35 per cent of the coal used in the country and of the economies due to the care of the engineers. He complimented Mr. Holbrook on the work he is doing in establishing a short course for engineers in connection with the Iowa State College at Ames, as an extension of the college work, so that every engineer may attend a short course somewhere during the year.

In his address, Mr. Holbrook gave a short summary of the history of engineering science and pointed out the progress that has been made in 100 yr. Now the engineer is coming to be recognized as one of the greatest builders of progress, who leaves behind as his monuments useful works for the benefit of mankind.

President Holbrook's address was characterized by those who heard it as an outstanding success and a brilliant response to the honors shown him during the evening.

News Notes

BURY COMPRESSOR CO. announces that the new location of its New York office will be at 50 Church St. and will be in charge of H. L. Dean.

CHARLES LONGENECKER, formerly Sales Engineer with the Bonnot Co. at Canton, Ohio, has become associated with the Combustion Engineering Corporation. Mr. Longenecker was one of the first men to specialize in pulverized fuel and he has been active in this field for many years past. His efforts have been directed particularly along the line of industrial application to both boilers and furnaces. In this new connection he will be identified with the recently created industrial department of the Combustion Engineering Corporation. This department, in charge of H. D. Savage, will specialize in the application of pulverized fuel to industrial work of all kinds.

COMBUSTION ENGINEERING CORP. and Green Engineering Co. announce the opening of an Indianapolis office located in the Guaranty Building under the direction of B. J. Schneider.

THE SALES engineering business formerly conducted under the name of Franklin, Williams, Inc., at 39 Cortlandt St., New York, has been taken over by F. N. Currier, a former member of that organization, who is continuing the business at the same address.

THE ASHMEAD-DANKS CO., Cleveland, Ohio, has recently been appointed district representative in the Northern Counties of the state of Ohio by W. H. Nicholson & Co. and will handle steam separators, eliminators and traps as well as other power plant specialties.

HENRY R. STICKNEY, inventor and manufacturer of the Stickney Steam Engine, died at his home in Portland, Me., Mar. 13, aged 65. He was one of the most widely known inventors of machinery in the East. He was the first successfully to apply the direct connection of steam engines with the rear axle of vehicles, thereby doing away with the use of chains. He invented and manufactured the Stickney milk condensing machine, and machinery for filling cans in canning foodstuffs, and was sole owner of the Stickney Manufacturing Co. of Portland.

PULVERIZING and combustion equipment for the third unit of Cahokia station has just been ordered from the Combustion Engineering Corp., according to a statement made by McClellan & Junkersfeld, Inc. Contract has also been let for the weighing and transport system with the Quigley Fuel Systems, Inc. These installations will be substantially duplicates of those now operating in units 1 and 2 in the first section. In addition to the foregoing regular equipment, one 70-in. Fuller-Lehigh Engineering Co. air separation pulverizing mill will be installed for comparison and trial purposes.

PLANS HAVE been completed for erection of an hydroelectric plant in the Northern part of Georgia that will develop 45,000 hp. and supply electrical energy for a new industrial section, according to an announcement by the Georgia Industrial Bureau. The dam will be erected on the Coosawattee River at a point in Gilmer county where the river is joined by Flat Creek and where it flows between two high cliffs and will be built of reinforced concrete, 250 ft. high. It is the purpose of the new company according to Dr. N. P. Pratt, owner of the property on which the dam is to be erected, to serve the cities and towns of extreme northern Georgia with power and lights.

THE COLUMBIA POWER CO., a subsidiary of the Columbia Gas & Electric Co., has recently ordered complete coal preparation, conveying and burning equipment for eight 1500-hp. Babcock & Wilcox boilers to be installed at the new Miami Fort Power Station. This equipment consists of six 57-in. Fuller-Lehigh screen type pulverizers, two 6 ft. 6 in. by 50 ft. Fuller-Kinyon pumps to distribute the fuel from the weigh bins to the boiler bins. Each boiler will be equipped with five Fuller triplex feeders driven by

variable speed motors. The boiler furnaces will be of hollow wall design with no water screens but economizers and air preheaters will be installed. The operating pressure will be 575-lb. gage and the total temperature of the steam approximately 725 deg. F. Generating equipment for the first unit will consist of two 40,000-kw. reheater turbines. The furnaces will be designed for average rating of 225 per cent with peak loads of 350 per cent.

Bids have been requested by the Des Moines Electric Co. for the contracts for the building of the first $6,000,000 unit of the company's proposed $16,000,000 power plant on the Des Moines River, southeast of Des Moines, according to an announcement by M. G. Linn, manager of the company. It is expected that building operations will start within the next thirty days.

Books and Catalogs

Power Plant Machinery, Volume I, Mechanism of Steam Engines, by Walter H. James and Myron W. Dole; second edition, size 6 by 9 in., 277 pages, cloth, New York, 1923.

Theoretically any piece of mechanism which is operated through the medium of steam is a steam engine and it is in this sense, apparently, that the authors have used the words in the title; otherwise it is a misnomer as material on turbine is also included.

Professedly, this book is intended as an elementary treatise on the kinematics, that is, the geometry of both reciprocating steam engines and steam turbines. Only sufficient attention is given to the behavior of the steam itself to enable the reader to comprehend intelligently the machine for which the steam is the source of power. In the general scheme of things the book fits in, following a course in the elements of mechanism and preceding a study of the theory of heat engineering.

Subjects which are given consideration may be topically classified as single-valve engines, valve diagrams, governing devices, riding cutoff valves, multiple valves, reversing and controlling gear, valve setting, steam, turbine and turbine valve mechanism and governors.

Mechanical World Electrical Pocket Book, 1924; 326 pages, size 4 by 6 in., cloth; Manchester, 1924.

Several new sections have been introduced in the present edition. That on accumulators or storage batteries has been considerably amplified and the subject of testing apparatus embodying descriptive particulars of various instruments in the latest practice has been included. Sections on lighting and welding have been revised to bring them up to date and new material on electric furnaces and thermoionic valves has been added.

Technical Paper 323-A, "United States Government specification for lubricants and liquid fuels and methods for testing," has just been issued by the Department of the Interior, through the Bureau of Mines. This specification, known as United States Government Standard Specification No. 2c, revised March 18, 1924, is a revision of the specification officially adopted by the Federal Specifications Board on Feb. 3, 1922, for the use of the Departments and independent establishments of the Government in the purchase of materials covered by it. Technical Paper 323-A includes specifications for aviation gasoline, motor gasoline, kerosene, marine and light house kerosenes, long-time burning oil, fuel oil and a considerable variety of lubricants. Methods for testing these various products are given in the paper. The paper may be obtained from the Superintendent of Documents, Government Printing Office, Washington, D. C., at a price of 15 cents.

Hills-McCanna Co., 2025 Elston Ave., Chicago, Ill., has just issued a general catalog describing in detail its forced feed lubricators and oiling appliances.

Homestead Valve Manufacturing Co., of Homestead, Pa., has issued a new catalog, No. 31, which describes the company's complete line of valves, including the Homestead quarter-turn lubricated valves.

Graver Corporation, East Chicago, Ind., has published an eight-page booklet describing the Graver intermittent water softener, which consists of two wooden tanks and a gravity filter. It is designed for raw water ice plants of 50 T. or less capacity and for the smaller boiler plants.

Marblehead Lime Co. of Chicago, Ill., has just published an attractive pamphlet describing its lime products for use in softening water. The action of lime on carbonates, the chemical re-action between soda ash and sulphates, and the preparation of hydrated lime from pure limestone are each discussed briefly.

William Reed Engineering Co. of Louisville, Ky., has issued an 8-page booklet on the subject of Air Filters. The material contained in this booklet is taken from an address on the subject before the American Society of Heating and Ventilating Engineers by J. H. Milliken. The paper takes up the characteristics of air filters and discusses their efficiencies and application.

Bulletin 726 recently issued by Warren Webster & Co., of Camden, N. J., describes the Webster boiler-return traps. This trap is designed for use in combination with other apparatus, in Webster Modulation Systems to remove the air entrained in the radiators and piping and to return the water of condensation automatically to the boilers regardless of the pressure carried therein, provided it is within the maximum working limit of 15 lb. per sq. in.

National U Bend Type storage heaters with steel shells and copper tubes are described in Bulletin No. 65 issued by the National Pipe Bending Co., of New Haven, Conn. The bulletin gives details of construction and tables of sizes and capacities for horizontal and vertical arrangement. The bulletin can be had on request to the National Pipe Bending Co., which is also developing a line of bleeder heaters for balanced heat control systems.

In the latest bulletin published by the Martindale Electric Co., 11745 Detroit Ave., Cleveland, Ohio, is a description of a new commutator cement which has just been brought out. This cement is mixed, ready for use and will keep several months without deterioration. The cement is prepared for use in replacing charred insulation, particularly mica between bars on commutators and for filling holes in commutators caused by short circuits.

"Static Condensers for Power Factor Correction" is the title of circular No. 1670 just issued by the Westinghouse Electric & Manufacturing Co. In this circular the need of power factor correction, the methods of obtaining high power factor and the method of selecting the proper corrective device for power factor are carefully analyzed and the fields of application of synchronous and static condensers set forth in diagrammatic form.